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CONTENTS

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CORRECTIONS

REVIEW, November, 1927:

Page 488, in the equation near the foot of the page, "1.54" should be "15.4."

Page 489, heading to Table 2, "495F" should be "4957"; same page, Table 3, in the first column head, change "centimeters" to "millimeters"; same column, below boxhead, change "Cm." to "Mm."

Page 490, headings to Tables 5 and 6, change "centimeters" to "millimeters."

Page 490, second column, first paragraph, fifth line, change "maximum" to "minimum."

Page 490, second column, in the heading to Table 7, the denominator of the fraction should be "total radiation" instead of "solar radiation."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

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THE WINTER ANTICYCLONE OF THE GREAT BASIN [1]

[Dated February, 1927]

ALFRED J. HENRY

In several respects the characteristics of this anticyclone are similar to those belonging to the so-called semipermanent anticyclones of the globe. Like the great Siberian anticyclone, it is clearly of seasonal origin and must be considered as the continental extension of the northeast Pacific anticyclone which has its greatest development in August in about north latitude 40°, west longitude about 150°.

The annual march of atmospheric pressure over a semiarid continental region, such as that of the Great Basin, is, of course, somewhat different from that over the ocean. Figure 1 shows the annual march of the monthly means of pressure at Boise, Idaho, a representative Great Basin station.

Pressure in the Great Basin rises from a minimum in May to a maximum in December, whereas pressure in the North Pacific anticyclone reaches its yearly maximum in August and diminishes thereafter to its minimum in January when its geographical center is about 950 miles almost due west from San Francisco, Calif. From that position offshoots may and do readily pass northward along the California coast, inland over Washington and Oregon, and thence by an easy step to the G. B. A.

The background for a clear understanding of the causes which conspire to create and maintain this anticyclone must be sought in the larger features of the general atmospherical circulation and the normal pressure distribution of the Northern Hemisphere. The large features of pressure distribution are: Low pressure in equatorial regions, a belt of high pressure surrounding the globe about latitude 35° in both hemispheres in which the high pressure is not continuous but broken up into separate centers of higher pressure over the oceans of which in the Northern Hemisphere the Azores HIGH over the eastern Atlantic and the northeast Pacific HIGH, already mentioned are prominent examples. There is also a second belt of low pressure near the sixtieth parallel best developed over the northeast Pacific and the same quarter of the Atlantic.

The belts of high pressure with which we are most directly concerned differ in the two hemispheres, the one in the Southern Hemisphere is roughly parallel with the Equator, while that of the Northern Hemisphere is of irregular outline and exhibits the greatest differences as regards breadth, latitude, and inclination to the Equator. These differences are due entirely to the great preponderance of land surface in the Northern as compared with the Southern Hemisphere. The basic cause of the G. B. A. is its geographic position on the western margin of the North American Continent in a dry region where the solar radiation in winter is largely reflected by the snow cover. The naturally large terrestrial radiation of the region also is at a maximum in winter, hence a part of the prevailing high pressure is purely a radiation effect. The region around the station Boise, Idaho,

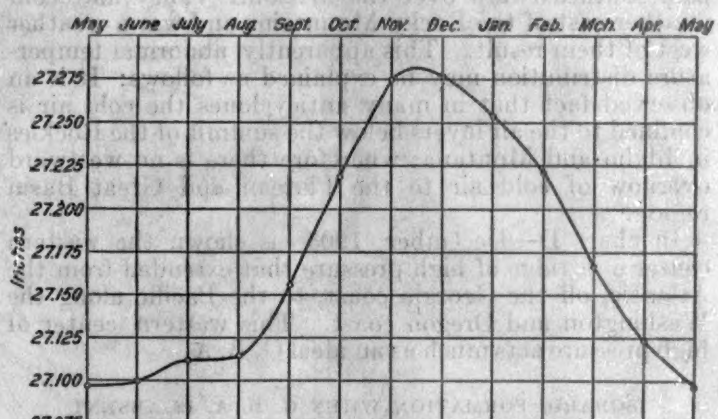


FIG. 1

seems to be one of large radiation opportunity and for that reason it has been chosen as the representative station of the Great Basin region.

The G. B. A. is at its greatest intensity in January; its maintenance and appearance of permanence are brought about substantially as follows: At least three important factors in the maintenance of the G. B. A. may be mentioned, first is the presence a few hundred miles offshore of the semipermanent anticyclone of the northeast Pacific offshoots from which readily pass inland in the rear of a cyclone moving eastward along the border between the United States and Canada, the normal course followed by oceanic storms which come in from the Pacific; second, as already mentioned, the terrestrial radiation of the Great Basin region by reason of its aridity is large and the cooling of the lower layers of the atmosphere due to this cause is augmented in no small degree by the loss of incoming solar radiation by reflection from the snow

[1] The term "Great Basin" is almost universally used by physiographers to include that extensive area of interior drainage that lies near the western margin of the continent. It is bounded on the north by the Columbia River Basin, on the east by that of the Colorado and on the west by the basins of the streams that have their source in the high Sierra. It is not a single cup-shaped depression gathering its waters at a common center, as the title might suggest, but rather a broad area of irregular surface, naturally divided into a number of independent drainage districts. Its extreme north-south length is about 800 miles and its widest part, say, in latitude 40° 30′ N., is 572 miles. The political subdivisions within it are almost the whole of Nevada, the western half of Utah, a strip along the eastern border of California, and a rather large, though for our purpose unimportant, area in the southeastern part of that State; also a rather large area in southeastern Oregon and, say, the southern half of Idaho. The locus of the Great Basin anticyclone (for which we shall use the abbreviation G. B. A. henceforth), is, however, confined to the north half of the basin.

cover in winter. These causes conspire to build up pressure over the Great Basin and to maintain it at a high level for 10 days to 2 weeks and even longer.

The anticyclone is dissipated temporarily when a succession of cyclonic storms from the Pacific or the Canadian northwest pass eastward along the border without the intervention of strong anticyclonic conditions. Each individual cyclone as it passes along the boundary is associated with a wave of falling pressure which extends some distance south of the cyclone center; thus it happens that at times so-called waves of falling pressure sweep over the Great Basin, the amplitude of the fall being larger in the northern than in the southern part of the basin. If, then, a number of consecutive impulses of falling pressure are received and there are no impulses of the opposite character to offset them, the center of the G. B. A. is progressively displaced to the southeast and finally disappears for a few days.

CHANGES IN FORM AND INTENSITY OF THE G. B. A.

As might be expected, the geographic position and intensity of this anticyclone are not the same in consecutive years. The variations most frequently experienced are shown in the series of small charts in Figure 2. Charts are also presented to show the contour of the isobars when the G. B. A. is absent.

Chart A is typical of the form of isobars in an ideal G. B. A., while charts B, C, and D are variations on the ideal type, of which perhaps C is the most important. In that type anticyclones from the Canadian northwest pass southeastward over the Missouri Valley and cold weather east of the Rocky Mountains and warm weather west of them result. This apparently abnormal temperature distribution may be explained as follows: It is an observed fact that in many anticyclones the cold air is confined to the air layers below the summit of the Rockies in Idaho and Montana; wherefore there is no westward overflow of cold air to the Plateau and Great Basin region.

In chart D—December, 1905—is shown the western center of a ridge of high pressure that extended from the Atlantic, off the Georgia coast, to the Pacific along the Washington and Oregon coast. This western center of high pressure acts much as an ideal G. B. A.

ISOBARIC FORMATION WHEN G. B. A. IS ABSENT

The four small charts, E, F, G, and H, show the types of pressure distribution in those months when the weather sequences were not favorable to the establishment and maintenance of the G. B. A. Chart E—January, 1909—shows a complete reversal from the usual anticyclonic conditions of January in the Great Basin, and chart F is much of the same order. The latter is made conspicuous by the fact that, although heavy rains fell in all California, not a single cyclonic storm passed inland south of the mouth of the Columbia River. Chart G—January, 1916—on the other hand, while pressure was generally low on the Pacific coast, several cyclonic storms passed inland over southern California, giving torrential rains in that part of the State. The last chart of the series is representative of a much weakened G. B. A. and also a month when the highest mean pressure was found over the Atlantic coast end of the winter high-pressure ridge.

When monthly mean pressure charts for the Pacific shall become available, one will doubtless see that when the isobars of the Pacific coast have the form illustrated by charts E and F the winter cyclone usually centered over the Aleutians will be found considerably to the southeast of its normal position. We may infer from the records of land stations that the center of the Aleutian LOW in each of the months represented by the four charts in question was not far from the coast of Washington and Oregon. World-wide meteorological statistics now available show that the low pressure in January, 1909, 1911, 1914, and 1916 were not confined alone to the northeast Pacific and the west coast of North America.

Statistics of January mean pressure at Boise, the representative station of the G. B. A., are presented in Table 1.

TABLE 1.—*Details of the Great Basin winter anticyclone*

Year	Sea level pressure			Departure from normal precipitation		
	At Boise (inches)	Maximum when not at Boise		North Pacific	Mid-Pacific	South Pacific
		Inches	Place			
January—						
1900	30.26	30.30	Grand Junction, Colo	−1.6	−0.6	−1.4
1901	30.18	30.32	do	−0.1	+1.0	+1.8
1902	30.30			−2.7	−3.9	−1.4
1903	30.23			−0.5	+0.3	−0.6
1904	30.30			−1.3	−3.6	−2.3
1905	30.26	30.41	Huron, S. Dak	−2.0	−0.3	−0.3
1906	30.26			−1.2	0.0	+0.6
1907	30.08	30.26	Huron, S. Dak	−1.3	+0.8	+2.8
1908	30.22	30.26	Pocatello, Idaho	−1.2	+0.5	+1.3
1909	29.97	30.21	Chattanooga, Tenn	+1.8	+6.9	+5.3
1910	30.27			+0.7	−1.2	−0.7
1911	30.12	30.29	Anniston, Ala	−0.4	+6.3	+4.4
1912	30.24			+0.9	−1.0	−1.7
1913	30.21			+0.7	−0.6	−0.8
1914	30.02	30.18	Durango, Colo	+5.9	+3.5	+5.7
1915	[1] 30.18			−1.3	+2.7	+2.3
1916	29.96	30.31	Miles City, Mont	−1.0	+6.2	+8.3
1917	30.31			−2.7	−2.2	−0.3
1918	30.16	30.21	Roseburg, Oreg	−0.8	−3.6	−2.0
1919	30.31	30.36	Grand Junction, Colo	+2.0	−1.5	−1.9
1920	30.34			−1.1	−4.2	−2.2
1921	30.13	30.16	Fresno, Calif	+1.6	+1.3	+0.7
1922	30.30			−3.9	−2.3	+1.0
1923	30.13	30.16	Sacramento, Calif	+2.3	−2.0	−0.6
1924	30.38			−2.3	−2.2	−2.2
1925	30.24	30.30	Grand Junction, Colo	−0.1	−2.8	−1.8
1926	30.33			−1.4	+0.1	−0.8
1927	30.22	30.28	Miles City, Mont	−0.5	−1.0	−1.2
Average	30.21					
Normal	30.185					

[1] The isobars of the G. B. A. were so oriented as to give southerly winds over California and abundant rains.

Whether the G. B. A. shall be fully or only partially developed is, of course, not known in advance, and its varying intensity must be considered as perhaps wholly fortuitous.

In the 28 months shown in Table 1, 8 had mean pressure of 30.3 inches or greater; 12 mean pressures ranging from 30.15 to 30.29 inches (sea level), and the remainder had means ranging from 29.97, the lowest, to 30.13 inches.

The tendency of cyclones to circle around the periphery of anticyclones is well established and this fact is well exemplified in the G. B. A. Obviously then when the Great Basin is occupied by an anticyclone, cyclones must avoid that region, which they do by passing eastward along the border between the United States and Canada or crossing California south of latitude 40° north and moving thence east-southeast to the Gulf of Mexico. It so happens, however, that there is usually little opportunity for cyclonic storms to enter the continent south of the latitude above given because cyclonic storms owe their origin to weather conditions that exist farther north rather than over the Pacific west of the coast of southern California.

GREAT BASIN ANTICYCLONE INIMICAL TO PRECIPITATION IN CALIFORNIA

The lack of precipitation in generous quantities in Pacific Coast States when the Great Basin is occupied by an anticyclone is because the winds in these States are then generally land winds and both cold and dry. The opportunity for precipitation is absent.

In the 28 years covered by the data of Table 1, normal, or better, rains fell in California in 1901, 1907–1909, 1911, 1914–1916, and 1921, in all in four periods counting as a single period both of the three consecutive years 1907–1909 and 1914–1916. Four rainy periods in 28 years suggests the seven-year period about which Clough has written.[2] I have given in Table 1 the monthly precipitation departures for the north, middle, and south Pacific climatological districts as published in the MONTHLY WEATHER REVIEW. These data show how intimate is the relation of precipitation to the pressure distribution on the Pacific coast, high pressure being associated with deficient rainfall and vice versa.

Since the low-pressure months have for us the greatest interest, I have discussed them in some details in the paragraphs that follow.

JANUARY, 1907, AND 1909

Meteorological observations outside of continental United States for these months are not at hand, but those of Pacific Coast States indicate quite clearly that for 1909, at least, pressure over the Gulf of Alaska was low and that pressure gradients on the Pacific coast were for southerly winds for the greater part of the month. (See chart E, fig. 2.)

It can be laid down with much confidence that months with more than normal precipitation in California are those in which pressure in the Gulf of Alaska is considerably below the average; as a consequence cyclonic wind systems, often of little intensity, impinge upon the land and sometimes, but not always, pass into the interior.

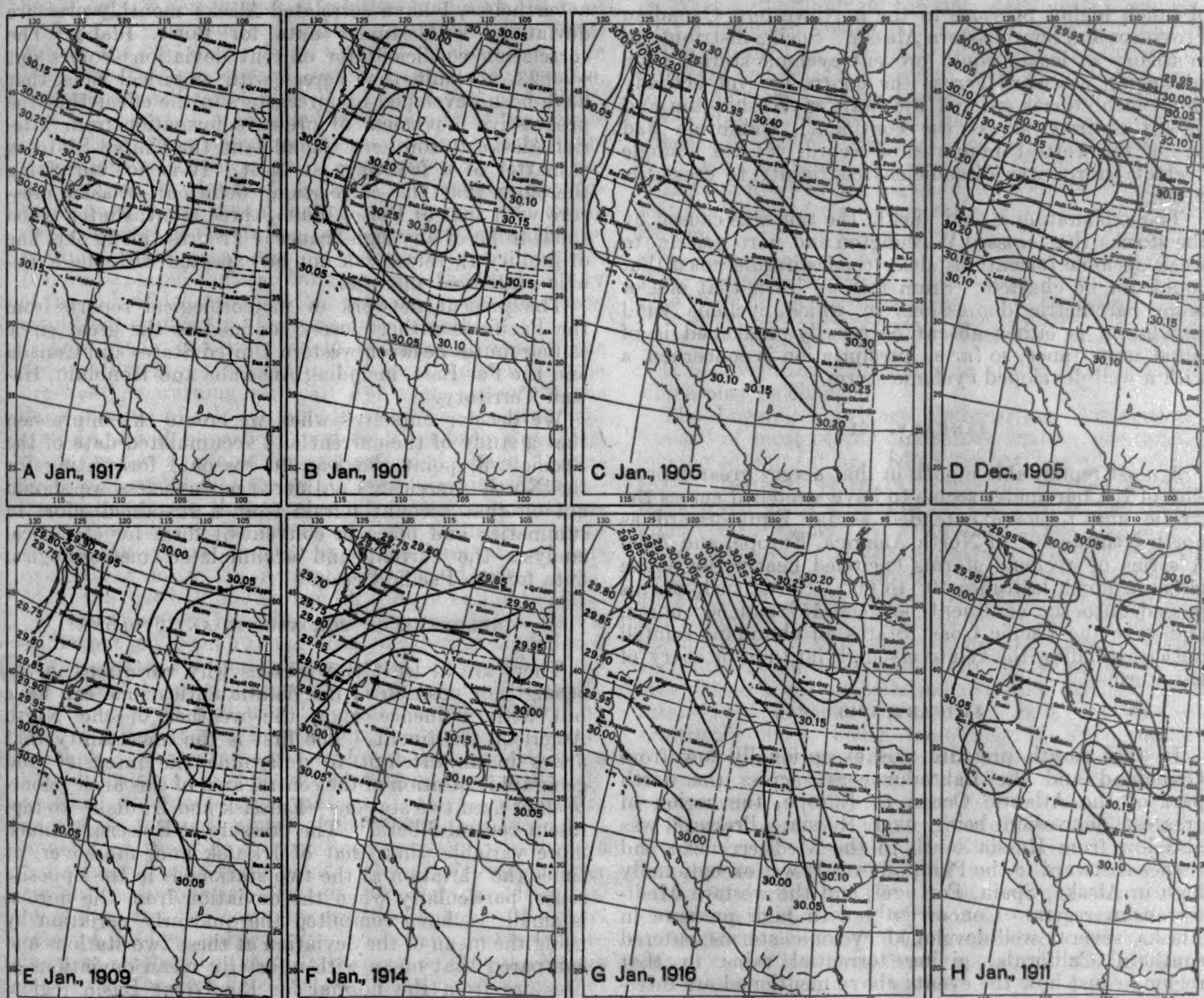


FIG. 2

[2] Clough, H. W. An approximate seven-year period in terrestrial weather with sol- correlation. MONTHLY WEATHER REVIEW 48:593.

In other words, the low-pressure center normally found over or near to the Aleutian group of islands is displaced to the southeast, the G. B. A. can not form, and southerly winds with abundant rains prevail in California.

JANUARY, 1911

The data for this month are less complete than for the two months next following; they show, however, an area of below-normal pressure in northwest United States and British Columbia protruding against an area of much higher pressure in the northwestern Canadian Provinces and Southeastern Alaska. Such a distribution, in theory at least, would prevent cyclonic storms from advancing eastward across the continent, yet actually three such storms entered the State of Washington and passed entirely across the continent. California had one of the wettest Januaries of record, yet not a single cyclonic storm was of sufficient continuity to cross the State.

The explanation is that part of the rain was caused by the storms that crossed Washington and part was due to weak cyclonic formations along the California coast that could not be charted. From this we learn that one or more barometric depressions in which cyclonic wind circulation is either absent or greatly weakened is of equal importance, so far as precipitation is concerned, a with a well-developed cyclonic storm.

JANUARY, 1914

A most remarkable month in that a very great depression of the barometer seems to have stretched across the Arctic and to have extended as far Equatorward as north latitude 40° in North America, Europe, and Asia. A series of cyclonic storms encircled nearly the entire globe in north latitudes 40° to 60°. Seven such storms passed onto the continent between 45° and 50° north, and gave the Pacific Coast States an abundant rainfall notwithstanding the relatively high latitude of entry of the storms.

JANUARY, 1916

In this month pressure was exceptionally low from Greenland and the Labrador coast across the north part of the Atlantic Ocean to Europe, the region of greatest depression being over Russia. Pressure was also low from Russia south to the Mediterranean and thence eastward to the Philippines. It was exceptionally high in Alaska, Spain, Portugal, and the western Mediterranean region. Concurrently with high pressure in Alaska several well-developed cyclonic storms entered southern California, giving torrential rains to that region. Just how the events above mentioned are interrelated is not known, although experience teaches us that prevailingly high pressure in the higher latitudes has a tendency to cause cyclonic storms to take a course farther south than usual.

CAN THE INTENSITY OF THE G. B. A. BE FORECAST?

The very intimate connection that subsists between pressure over Pacific Coast States and rainfall in California leads at once to the above query.

The method of correlation used to good advantage by Walker and others comes at once to mind. Since the drift of the weather is from west to east, one naturally thinks of the weather of the Pacific Ocean between the North American coast line and, say, the coast of Japan. While the mass of observational material for this area is slowly increasing, it is yet scarcely practicable to construct monthly averages of pressure distribution over the ocean surface without the expedient of extrapolation to a rather large extent. The monthly averages derived from island stations are either too short or the island station is badly situated geographically; Honolulu, for example, is too far south to represent pressure changes in the north Pacific anticyclone, and the record of Alaskan stations at best is less than 12 to 15 years; nevertheless, I have correlated Alaska monthly pressure deviations with similar data for Boise, Idaho. The correlation coefficient for current deviations comes out $\gamma=0.23$, a result that agrees with empirical rules that have been developed by forecasters to the effect that the progressive movement of pressure formation from interior Alaska to southern Canada and the United States is a matter of a few days at most. It is not surprising therefore that the correlation coefficient, Alaska pressure with that of Boise, Idaho, three months later is too small to be of any significance. Progress along this line of inquiry therefore can not be expected with the available statistical material.

The present network of meteorological reports from the Pacific is rather closely confined to the great circle sailing routes between western United States and Canada and the Far East, including Australia and Honolulu, Hawaii Territory.

We deceive ourselves when we create the impression that a study of the current and accumulated data of the Pacific will point the way to seasonal forecasting for the North American Continent; nevertheless we should not on that account refrain from a sustained effort to summarize and place in convenient form for statistical analysis the current and accumulated meteorological data for the Pacific Ocean.

INFLUENCE OF THE ASIATIC ANTICYCLONE

There are at least two reasons why variations in the strength or position of the Asiatic anticyclone can have but little influence upon the weather of the North American Continent. The first is the uncertainty that arises in an attempt to determine the intensity and geographic position of the central area of this anticyclone. Walker used two stations—Eniseisk and Irkutsk—to represent central Siberia. The pressure at Eniseisk is much more variable than that of Irkutsk and, moreover, at times the variation at the two stations is in the opposite sense, particularly when the deviation from the normal is small. I have computed the quarterly variation by using the mean of the deviation at these two stations and compared that mean with quarterly mean deviations of pressure from the normal for the Great Basin region. This comparison shows that there is little or no prevision in the Asiatic anticyclonic pressures.

The second reason is that offshoots from the Asiatic anticyclone must, in general, move Equatorward over the ocean. In so moving, by reason of greatly reduced radiation from a water surface as compared with a land surface, they must decrease in intensity as they pass over the water; the original offshoots, moreover, probably never reach the American Continent, except as modified by the long oceanic journey and the pressure conditions encountered en route. On the other hand anticyclones that may move into northeastern Siberia from polar seas may easily drift over Alaska and thus in a measure affect the movement of cyclones over the United States.

THE FREQUENCY AND PERSISTENCE OF LOW RELATIVE HUMIDITY IN THE STATE OF WASHINGTON

By George W. Alexander

[Fire-Weather Warning Service, Seattle, Wash., March 10, 1928]

With this paper there are presented tabulated data as to the frequency of occurrence of days marked by a low percentage of relative humidity, within certain stated brackets, and the coefficients of probability of the occurrence of such days. The totals and averages stated are based on the percentages of relative humidity observed at 5 p. m., one hundred and twentieth meridian time, during the 34 years, 1894 to 1927, inclusive, at the Weather Bureau stations at North Head, Seattle, Spokane, and Walla Walla, Wash., and Portland, Oreg. The latter station is included in this study of conditions in Washington as being more representative of conditions in portions of southwestern Washington than any of the stations within the State. Certain adjusted interpolations have been made for periods during which the records at two of the stations were incomplete, so that the resultant calculations may be more closely comparable. It may be stated that the omission from the totals of any of the individual months which include interpolated data would not materially affect the averages stated.

This study has been made in connection with the fire-weather investigations in the Seattle district of the fire-weather warning service. For such a purpose the daily minima of relative humdity at representative field stations would have been preferable as basic data, but these are not available for any extended period. Comparison of such field data as are available with those employed has shown that there is a sufficiently close agreement that the records herein set forth do indicate quite closely the general tendencies in the forested and cut-over areas near the several stations. During April, May, the first half of June, and the latter half of September, the minimum humidity usually occurs before, and is somewhat lower than that at 5 p. m.; during the balance of the season, the midsummer period, during which the fire hazard is usually greatest, the minimum frequently occurs nearly at, and usually is in close agreement with that recorded at that hour. For this reason the upper brackets of percentages chosen for analysis include some humidities that are slightly higher than those ordinarily assumed to denote any material increase in the fire hazard, in the earlier part of the season, but the actual minima of those days may have been at or below the tentatively fixed danger point. During the midsummer season the cumulative effect of preceding periods of low humidity, and the normal seasonal changes in the character of the fuel, particularly the annual growth, tend to increase reaction to the daily changes, so that the figures taken may be considered as very nearly indicating that condition which, in Washington, is commonly called "fire weather."

It should be stated, parenthetically, that while the subject of fire weather is a complex one, and it is recognized that many factors must be considered in any investigation concerning it, in the Pacific northwest, and particularly in the regions west of the Cascade summits, it is assumed by most of the officials of forest protective agencies that, other things being equal, and due weight being given to the seasonal changes in the character of the fuel, the variations in the percentage of relative humidity prevailing over a given area may be accepted as an index of the variations in the fire hazard in that area. Two examples of the weight given the "humidity theory' may be cited.

Early in the season of 1927 the State supervisor of forestry and the chief fire warden of the Washington Forest-Fire Association, charged with forest protection in Washington (outside the national forests), requested that a standard nomenclature, descriptive of the degree of the expected fire hazard, be adopted for all fire-weather forecasts and warnings sent to their wardens and issued to the public through the press and by radio telephone. After discussion, and reference to other protective officials, the following was adopted, as best indicating the expected conditions, and was used thereafter in formulating the fire-weather forecasts for western Washington sections issued from the Seattle office of the Weather Bureau.

Expected minimum humidity	Terminology of the forecast
50 per cent or higher	Fire hazard slight.
49 to 39 per cent, inclusive	Fire hazard moderate.
30 to 38 per cent, inclusive	Fire hazard dangerous.
29 per cent or lower	Fire hazard extremely dangerous

It is recognized that this is an arbitrary classification, which may be changed.

The Logging Insurance Underwriters Association, a "pool" of most of the companies writing insurance on logging equipment and felled timber, has adopted a so-called "humidity warranty," under the provisions of which the assured, by maintaining on his logging operation an approved instrument for recording the percentage of relative humidity and the temperature (the model 1927 hygro-thermograph is generally used for this purpose) and an approved psychrometer, by which the accuracy of the recording instrument may be checked at intervals, and undertaking to cease active logging operations during such time as the relative humidity is below 30 per cent, may obtain a very substantial reduction in his premium rate. This danger point of 30 per cent was also arbitrarily fixed, being something of a compromise. It is still the subject of discussion, although, in the opinion of many of the protective officials, it is sufficiently conservative.

These two practical applications of the humidity theory, the increasing interest in the subject, together with the frequent requests for data as to the conditions to be expected during the fire season, and the frequency of those conditions regarded as dangerous, may serve to indicate the necessity for so detailed an analysis of the occurrence of low humidity as is given in the tabulations that follow.

For convenience, the six months, April to September, inclusive, are considered as the fire season. It is true that abnormally low humidities and fires do occur during the other months, March and October particularly. The low humidities for these two months might have been included in the tabulations, but the occurrences are so infrequent that no particular purpose would be served thereby. During them the degree of fire hazard and the actual amount of damage seem to depend largely on other abnormalities of the weather, more particularly on marked deficits in the seasonable precipitation.

The data for Seattle and Portland are fairly representative of general conditions in the interior of western

Washington and the lower western slopes of the Cascades, although the tendencies in the sheltered valleys of the Cascade system are for generally higher temperatures and lower humidities. The nature of the variations at the individual stations depends largely on orographic influence. There is a more limited application of the data for North Head. This station is particularly exposed to maritime influences, low humidity is noted only when the winds are from easterly quarters, outflowing from a HIGH over the plateau. The relative humidity over the area just a short distance inland from this station is generally several per cent lower than on the immediate

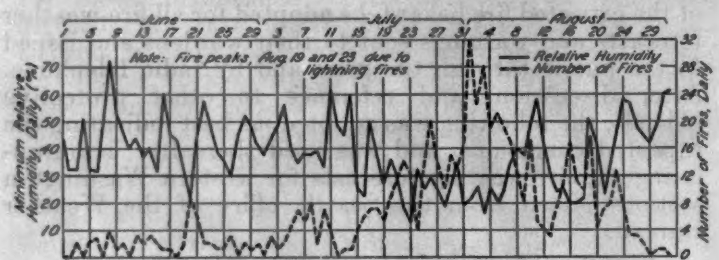


FIG. 1.—Minimum relative humidity and number of fires

coast, hence the high index figure chosen for the tabulation. Conditions here may be taken as representative of the "fog belt" along the Washington coast, to the westward of the Olympics and the Coast Range.

In the eastern sections the humidities at Spokane and Walla Walla are in close correspondence with those in the field in their vicinities, and are somewhat lower than those reported at certain stations on the eastern Cascades and in the Okanogan highlands. The highest percentage tabulated (25) is close to the 5 p. m. normal for July and August at the two Weather Bureau stations. In general, the number of occurrences of subnormal humidities in the field and at these stations is in close agreement. In the practical application of these data, for all sections, it must be borne in mind that the local peculiarities of climate, as shown by the amount and distribution of precipitation, the prevailing temperatures, and the frequency of lightning storms, as well as the local differences in the forest types and fuel materials, must all be given due consideration.

Tables 1 and 2 show the total number and the monthly and seasonal averages of days with relative humidity within the indicated brackets, with the extremes, and the years of their occurrence, for each bracket. Table 3 shows the coefficients of the probability of the occurrence of a day of such relative humidity. Some rather interesting points are brought out by the figures shown.

It will be noted that at all stations, except North Head, the total number, the averages, the probability of the occurrence of humidity within the upper brackets, and the monthly totals for all days with humidity below the upper index figure vary directly with the normal variations in temperature and hours of sunshine throughout the year, and inversely with the monthly precipitation. For North Head the opposite is true for all brackets and for the totals. At Seattle there is an irregularity in the "30 per cent to 26 per cent" bracket, and a marked reversal in the two lowest. At Portland the reversal appears in the two lowest brackets, although to a smaller extent. From these figures we may infer, and the inference is supported by a more detailed study of the individual cases, that marked abnormalities in the percentage of relative humidity on the immediate coast are caused by marked departures from the normal conditions as to wind direction and absolute humidity; specifically, to the dominance of HIGHS over the plateau. These are more frequent in April, May, and September than in June, July, and August. This same inference holds with regard to the more marked abnormalities at Seattle and Portland; that is, extremely low relative humidity is most frequently attendant on the conditions just stated, and the more frequent and less pronounced departures from the normal (shown in the two upper brackets) are due more frequently to those conditions which are favorable for higher temperatures while causing no great change in the absolute humidity. Or, stated more generally, seasonal variations with slight abnormalities appear while the normal maritime climate prevails, the degree of the departures depending on the position of the Pacific HIGH, as causing northerly or westerly winds. The variations abnormal to the season occur when there is an intrusion of the continental climatic régime over western Washington, under the dominance of the plateau HIGH.

For the eastern sections no such abnormalities appear. The peak of probability for all brackets and the totals appears in July, actually in the latter half of that month. The most marked abnormality in the occurrence of low humidity in the northeastern section (Spokane), a decreasing or stationary low humidity as the accompaniment of decreasing temperature and fresh to strong southeasterly winds, is due to local conditions, orographic to some extent, but more to the nature of the terrain over which the southwesterly winds have traveled. This does not show up in the tabulations, as it is more frequent during the warmer months.

Of equal, or perhaps greater, importance than the number of days with low relative humidity is the tendency for recurrence, or occurrence on consecutive days. One day, or a few hours, of such low humidity may not affect the fuel so as to cause any appreciable change in the degree of the fire hazard, but, whatever of effect may be ascribed, it is obvious that the longer the period over which it prevails the greater the ultimate effect on

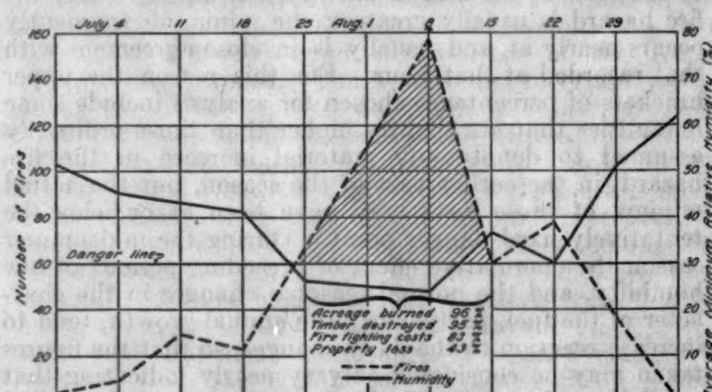


FIG. 2.—Weekly fire occurrence and its relation to average minimum relative humidit

the fire material. To cover this phase, Table 4 shows the number of occurrences of consecutive days of low relative humidity, within the limits and in the several day groups as indicated.

Table 5 shows the average number of periods (groups of one or more days) and Table 6 the average duration of such period, with the extreme, and its date, for each classification. A study of these figures seems to confirm the inferences previously noted as based on Tables 1, 2, and 3. The persistence curve, if expressed graphically, would vary somewhat from that for occurrence, at

Seattle and Portland, but would be altogether in accord at the eastern stations. The abnormalities noted for North Head and for the lower brackets at Seattle and Portland are just as apparent.

In Table 7 there is a chronological list of the occurrences of low humidity at each station during the period covered by this study. This is offered for the information of those who may wish to correlate fire occurrences or other phenomena with the occurrence of low humidity, as these figures are not available in any published data, as are those for precipitation and temperature.

THE OCCURRENCE OF LOW RELATIVE HUMIDITY

Totals and averages are based on the 34-year period, 1894–1927, for all stations.

TABLE 1.—*Total number of days with relative humidity as indicated (5 p. m. observation)*

Relative humidity (per cent)	April	May	June	July	August	September	Season
AT SEATTLE, WASH.							
38 to 31, inclusive	83	108	135	163	145	58	692
30 to 26, inclusive	30	22	42	30	26	10	160
25 to 20, inclusive	23	24	17	9	4	7	84
19 or lower	10	7	4	1	0	1	23
Total, 38 or lower	146	161	198	203	175	76	959
AT PORTLAND, OREG.							
38 to 31, inclusive	96	102	102	187	175	67	729
30 to 26, inclusive	45	53	52	73	71	34	328
25 to 20, inclusive	60	34	29	28	27	17	195
19 or lower	19	15	15	13	12	15	89
Total, 38 or lower	220	204	198	301	285	133	1,341
AT NORTH HEAD, WASH.							
50 to 41, inclusive	14	9	3	3	2	17	48
40 to 31, inclusive	8	3	0	1	2	16	30
30 or lower	3	3	3	0	3	7	19
Total, 50 or lower	25	15	6	4	7	40	97
AT SPOKANE, WASH.							
25 to 20, inclusive	164	183	235	262	252	202	1,298
19 to 15, inclusive	78	81	139	280	276	85	939
14 or lower	18	24	51	177	163	22	455
Total, 25 or lower	260	288	425	719	691	309	2,692
AT WALLA WALLA, WASH.							
25 to 20, inclusive	107	138	187	268	264	116	1,080
19 to 15, inclusive	37	57	121	227	217	43	702
14 or lower	16	12	34	150	109	8	329
Total, 25 or lower	160	207	342	645	590	167	2,111

TABLE 2.—*Average number of days with relative humidity as indicated, monthly and for season, with seasonal extremes, period 1894–1927*

Relative humidity (per cent)	April	May	June	July	August	September	Season	Greatest number	Year	Least number	Year
AT SEATTLE, WASH.											
38 to 31, inclusive	2.5	3.2	4.0	4.8	4.4	1.7	20.6	39	1926	4	1905
30 to 26, inclusive	0.9	0.6	1.2	0.9	0.8	0.3	4.7	13	1927	0	[1] 1913
25 to 20, inclusive	0.7	0.7	0.5	0.3	0.1	0.2	2.5	9	1898	0	[1] 1904
19 or lower	0.3	0.2	0.1	0.03	0	0.03	0.7	4	1926	0	[1] 1904
38 or lower	4.4	4.7	5.8	6.0	5.3	2.2	28.4	65	1926	5	1913

TABLE 2.—*Average number of days with relative humidity as indicated, monthly and for season, with seasonal extremes, period 1894–1927*—Continued

Relative humidity (per cent)	April	May	June	July	August	September	Season	Greatest number	Year	Least number	Year
AT PORTLAND, OREG.											
38 to 31, inclusive	2.8	3.0	3.0	5.5	5.1	2.0	21.4	37	1904	7	1925
30 to 26, inclusive	1.3	1.6	1.5	2.1	2.1	1.0	9.6	21	1918	3	1899
25 to 20, inclusive	1.8	1.0	0.9	0.8	0.8	0.5	5.7	17	1918	0	1908
19 or lower	0.6	0.4	0.4	0.4	0.3	0.4	2.6	7	[1] 1895	0	[1] 1899
38 or lower	6.4	6.0	5.8	8.8	8.3	3.9	39.3	69	1918	16	[1] 1912
AT NORTH HEAD, WASH.											
50 to 41, inclusive	0.41	0.26	0.09	0.09	0.06	0.50	1.41	5	1896	0	(2)
40 to 31, inclusive	0.23	0.09	0.00	0.03	0.06	0.47	0.88	6	1926	0	(2)
30 or lower	0.09	0.09	0.09	0.00	0.09	0.21	0.56	3	[1] 1922	0	(2)
50 or lower	0.74	0.44	0.18	0.12	0.21	1.17	2.85	9	1926	0	(2)
AT SPOKANE, WASH.											
25 to 20, inclusive	4.8	5.4	6.9	7.7	7.4	5.9	38.3	50	[1] 1920	29	1927
19 to 15, inclusive	2.3	2.4	4.1	8.2	8.1	2.5	27.6	44	[1] 1918	12	1909
14 or lower	0.5	0.7	1.5	5.2	4.8	0.7	13.1	38	1895	1	[1] 1902
25 or lower	7.6	8.5	12.5	21.1	20.3	9.1	79.2	113	1924	50	1927
AT WALLA WALLA, WASH.											
25 to 20, inclusive	3.1	4.2	5.5	7.9	7.8	3.3	31.8	51	1921	5	1902
19 to 15, inclusive	1.1	1.7	3.6	6.6	6.4	1.3	20.6	46	1924	1	1902
14 or lower	0.5	0.3	1.0	4.4	3.2	0.2	9.7	33	1910	0	(2)
25 or lower	4.7	6.1	10.1	18.9	17.4	4.9	62.2	109	1910	6	1902

[1] And other seasons. (2) Several seasons.

TABLE 3.—*Coefficients of the probability of the occurrence of a day of low relative humidity, as indicated*

Relative humidity (per cent)	April	May	June	July	August	September	Season
AT SEATTLE, WASH.							
38 to 31, inclusive	0.081	0.102	0.132	0.155	0.138	0.057	0.113
30 to 26, inclusive	.029	.021	.041	.028	.025	.010	.026
25 to 20, inclusive	.023	.023	.017	.008	.004	.007	.013
19 or lower	.010	.006	.004	.001	0	.001	.004
38 or lower	.143	.153	.194	.192	.166	.074	.154
AT PORTLAND, OREG.							
38 to 31, inclusive	0.094	0.097	0.100	0.177	0.166	0.066	0.117
30 to 26, inclusive	.044	.051	.051	.069	.066	.033	.053
25 to 20, inclusive	.059	.032	.028	.027	.026	.017	.031
19 or lower	.019	.014	.015	.012	.011	.015	.015
38 or lower	.218	.194	.194	.286	.270	.130	.216
AT NORTH HEAD, WASH.							
50 to 41, inclusive	0.014	0.008	0.003	0.003	0.000	0.017	0.007
40 to 31, inclusive	.008	.003	.000	.001	.002	.016	.005
30 or lower	.003	.003	.003	.000	.003	.007	.003
50 or lower	.024	.014	.006	.004	.005	.039	.015
AT SPOKANE, WASH.							
25 to 20, inclusive	0.161	0.174	0.230	0.248	0.230	0.198	0.209
19 to 15, inclusive	.076	.077	.137	.266	.262	.083	.151
14 or lower	.018	.023	.050	.168	.155	.022	.073
25 or lower	.255	.273	.417	.682	.656	.303	.433
AT WALLA WALLA, WASH.							
25 to 20, inclusive	0.105	0.131	0.183	0.254	0.250	0.114	0.174
19 to 15, inclusive	.036	.054	.119	.215	.206	.042	.111
14 or lower	.016	.011	.033	.142	.104	.008	.053
25 or lower	.157	.196	.335	.612	.560	.164	.339

THE PERSISTENCE OF LOW RELATIVE HUMIDITY

Number of occurrences of consecutive days of low relative humidity, within the limits and in the several day groups as indicated.

TABLE 4

AT SEATTLE, WASH.

GROUPS OF DAYS, RELATIVE HUMIDITY 38 PER CENT, OR LOWER

	Number of days										
	1	2	3	4	5	6	7	8	9	10	11
April	51	16	8	6	3	0	0	0			
May	35	26	8	4	2	4	1	0			
June	35	24	15	5	7	1	1	0			
July	56	26	10	7	2	3	0	2			
August	61	23	10	5	1	1	0	0			
September	34	6	1	3	2	0	0	0			
Season	272	121	52	30	17	9	2	2			

GROUPS OF DAYS, RELATIVE HUMIDITY 30 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	27	8	4	0	1						
May	26	8	1	1	1						
June	37	7	1	0	1						
July	25	4	3	0	0						
August	19	3	1	0	1						
September	9	3	1	0	0						
Season	143	33	11	1	4						

GROUPS OF DAYS, RELATIVE HUMIDITY 25 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	20	3	1	1							
May	16	4	1	1							
June	15	3	0	0							
July	8	1	0	0							
August	4	0	0	0							
September	6	1	0	0							
Season	69	12	2	2							

GROUPS OF DAYS, RELATIVE HUMIDITY 19 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	6	2									
May	7	0									
June	4	0									
July	1	0									
August	0	0									
September	1	0									
Season	19	2									

AT PORTLAND, OREG.

GROUPS OF DAYS, RELATIVE HUMIDITY 38 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	52	30	9	6	3	4	2	0	1		
May	46	22	12	8	3	3	1	0	1		
June	44	22	12	6	2	3	3	3			
July	55	38	22	5	9	3	2	1			
August	66	31	18	6	1	4	2	0	1	0	1
September	33	23	7	3	1						
Season	296	166	80	34	19	17	10	4	3	0	1

GROUPS OF DAYS, RELATIVE HUMIDITY 30 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	32	18	9	5	1	1					
May	37	17	6	2	1						
June	24	15	6	3	0	1	1				
July	52	15	5	3							
August	54	14	6	2	0	1					
September	35	8	3	1							
Season	234	87	35	16	2	3	1				

GROUPS OF DAYS, RELATIVE HUMIDITY 25 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	26	14	7	1							
May	22	8	1	2							
June	22	6	3								
July	29	5									
August	22	5	1	1							
September	16	5	3								
Season	137	43	15	4							

TABLE 4—Continued

AT PORTLAND, OREG.—Continued

GROUPS OF DAYS, RELATIVE HUMIDITY 19 PER CENT OR LOWER

	Number of days										
	1	2	3	4	5	6	7	8	9	10	11
April	11	4									
May	9	3									
June	10	1	1								
July	13										
August	10	1									
September	9	3									
Season	62	12	1								

AT NORTH HEAD, WASH.

GROUPS OF DAYS, RELATIVE HUMIDITY 50 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	15	5									
May	9	3									
June	6										
July	4										
August	5	1									
September	28	8		1							
Season	59	17	0	1							

GROUPS OF DAYS, RELATIVE HUMIDITY 40 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	9	1									
May	3	2									
June	3	0									
July	1	0									
August	5	0									
September	21	1									
Season	42	4									

GROUPS OF DAYS, RELATIVE HUMIDITY 30 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11
April	3	0									
May	1	1									
June	3	0									
July	0	0									
August	3	0									
September	7	0									
Season	15	1									

AT SPOKANE, WASH.

GROUPS OF DAYS, RELATIVE HUMIDITY 25 PER CENT OR LOWER

	Number of days																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
April	72	29	14	6	6	1	0	1	2	0	1	1					
May	69	28	14	9	5	5	0	2	1	1	0	0	0	0	0	0	1
June	42	33	12	7	2	9	6	3	4	4	0	0	0	1	1	0	0
July	32	12	9	9	12	6	2	8	5	2	3	3	1	0	3	1	3
August	25	24	13	10	12	7	5	1	3	3	3	2	2	2	3	1	0
September	54	20	14	8	7	2	1	1	0	0	1	1	0	0	0	0	0
Season	294	146	76	49	44	30	14	16	15	10	8	7	3	3	7	2	4

	Number of days																
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
April																	
May																	
June	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
July	2	1	2	0	1	1	1	0	0	0	0	0	0	0	1	0	0
August	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
September	1																
Season	6	1	2	0	1	1	1	1	0	0	0	0	0	1	1	1	1

TABLE 4—Continued

AT SPOKANE, WASH.—Continued

GROUPS OF DAYS, RELATIVE HUMIDITY 19 PER CENT OR LOWER

	Number of days																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
April	36	13	4	2	0	1	0	1	-	-	-	-	-	-	-	-	-	-	-
May	43	7	7	3	0	2	-	-	-	-	-	-	-	-	-	-	-	-	-
June	34	16	11	8	5	5	3	0	1	-	-	-	-	-	-	-	-	-	-
July	55	23	20	7	3	9	6	4	2	5	1	1	1	0	2	0	0	1	-
August	45	29	13	13	12	4	3	1	2	1	2	0	0	0	2	0	0	0	1
September	37	12	3	2	0	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Season	250	100	58	35	20	23	12	6	6	6	3	1	1	0	4	0	0	1	1

GROUPS OF DAYS, RELATIVE HUMIDITY 14 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
April	12	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	14	2	0	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-
June	25	7	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July	54	20	8	5	4	0	1	0	1	-	-	-	-	-	-	-	-	-	-
August	43	19	8	3	3	0	0	1	1	1	-	-	-	-	-	-	-	-	-
September	16	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

AT WALLA WALLA, WASH.

GROUPS OF DAYS, RELATIVE HUMIDITY 25 PER CENT OR LOWER

	Number of days													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
April	42	17	10	7	2	0	1	1	-	-	-	-	-	-
May	44	23	11	9	3	3	1	2	1	-	-	-	-	-
June	31	25	11	6	9	4	4	4	4	0	0	0	0	2
July	30	19	13	12	7	3	9	6	3	3	4	3	0	1
August	39	15	14	7	10	4	7	2	3	4	0	0	2	0
September	45	18	6	4	4	0	1	-	-	-	-	-	-	-
Season	231	117	65	45	35	14	23	15	11	7	4	3	2	3

	Number of days													
	15	16	17	18	19	20	21	22	23	24	25	29	39	42
April	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	1	0	1	-	-	-	-	-	-	-	-	-	-	-
July	2	1	1	1	-	-	0	1	0	0	2	1	1	1
August	1	1	0	1	-	-	0	0	0	0	1	-	-	-
September	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Season	4	2	2	2	-	-	0	1	0	0	3	1	1	1

GROUPS OF DAYS, RELATIVE HUMIDITY 19 PER CENT OR LOWER

	Number of days															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
April	24	7	1	3	-	-	-	-	-	-	-	-	-	-	-	-
May	31	10	6	-	-	-	-	-	-	-	-	-	-	-	-	-
June	39	16	11	5	3	2	2	1	-	-	-	-	-	-	-	-
July	61	23	9	10	4	4	3	5	1	3	2	0	0	0	1	1
August	63	22	14	8	12	1	3	3	1	0	0	1	-	-	-	-
September	18	11	1	1	1	-	-	-	-	-	-	-	-	-	-	-
Season	236	89	42	27	20	7	8	9	2	3	2	1	0	0	1	1

GROUPS OF DAYS, RELATIVE HUMIDITY 14 PER CENT OR LOWER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
April	11	1	0	1	-	-	-	-	-	-	-	-	-	-	-	-
May	8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June	20	5	1	1	-	-	-	-	-	-	-	-	-	-	-	-
July	46	12	9	2	5	2	0	1	-	-	-	-	-	-	-	-
August	46	14	7	3	-	-	-	-	-	-	-	-	-	-	-	-
September	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Season	137	34	17	7	5	2	0	1	-	-	-	-	-	-	-	-

TABLE 5.—*The average number of periods (groups of one or more days) of low relative humidity, for the 34-year period*

AT SEATTLE, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season
38 or lower	2.5	2.4	2.6	3.1	3.0	1.4	14.9
30 or lower	1.2	1.1	1.7	0.9	0.7	0.4	5.6
25 or lower	0.7	0.6	0.5	0.3	0.1	0.2	2.5
19 or lower	0.2	0.2	0.1	(1)	0	(1)	0.6

[1] Less than 0.05.

AT PORTLAND, OREG.

Relative humidity (per cent)	April	May	June	July	August	September	Season
38 or lower	3.1	2.8	2.8	4.0	3.8	2.0	18.5
30 or lower	1.9	1.8	1.5	2.2	2.3	1.4	11.1
25 or lower	1.4	1.5	0.9	1.0	0.9	0.7	5.9
19 or lower	0.4	0.4	0.4	0.4	0.3	0.4	2.2

AT NORTH HEAD, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season
50 or lower	0.59	0.35	0.18	0.12	0.18	0.85	2.26
40 or lower	0.29	0.12	0.09	0.03	0.15	0.56	1.24
30 or lower	0.09	0.06	0.09	0.00	0.09	0.21	0.53

AT SPOKANE, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season
25 or lower	3.9	4.0	3.7	3.5	3.5	3.2	21.9
19 or lower	1.7	1.8	2.4	4.1	3.8	1.6	15.5
14 or lower	0.4	0.5	1.1	2.7	1.2	0.6	7.6

AT WALLA WALLA, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season
25 or lower	2.4	2.9	3.0	3.6	3.3	2.3	17.4
19 or lower	1.0	1.4	2.3	3.7	3.8	0.9	13.2
14 or lower	0.4	0.3	0.8	2.3	2.1	0.2	5.9

TABLE 6.—*The average duration of periods of low relative humidity for the 34-year period, with date and duration of longest period*

AT SEATTLE, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season	Longest period with date
38 or lower	1.7	2.0	2.3	1.9	1.7	1.7	1.9	8; July, 1911 and 1927.
30 or lower	1.6	1.4	1.5	1.2	1.2	1.4	1.4	5; several dates.
25 or lower	1.3	1.4	1.2	1.1	1.0	1.1	1.2	4; April, 1921; May 1898.
19 or lower	1.2	1.0	1.0	1.0	0	1.0	1.0	2; April, 1907 and 1924.

AT PORTLAND, OREG.

Relative humidity (per cent)	April	May	June	July	August	September	Season	Longest period with date
38 or lower	2.1	2.1	2.1	2.2	2.2	2.0	2.1	11; August, 1923.
30 or lower	1.9	1.6	1.9	1.5	1.4	1.4	1.6	7; July, 1898.
25 or lower	1.6	1.5	1.4	1.2	1.3	1.3	1.4	4; several dates.
19 or lower	1.3	1.2	1.2	1.0	1.1	1.2	1.2	3; June, 1920.

AT NORTH HEAD, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season	Longest period with date
50 or lower	1.2	1.2	1.0	1.0	1.2	1.4	1.3	4; September, 1926.
40 or lower	1.1	1.5	1.0	1.0	1.0	1.2	1.2	Do.
30 or lower	1.0	1.5	1.0	0	1.0	1.0	1.1	2; May, 1922.

AT SPOKANE, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season	Longest period with date
25 or lower	2.0	2.1	3.3	6.0	5.8	2.8	3.6	34; June-July, 1925.
19 or lower	1.7	1.7	2.3	3.3	3.4	1.9	2.6	19; August, 1904.
15 or lower	1.2	1.4	1.4	1.9	2.1	1.2	1.8	10; August, 1894.

AT WALLA WALLA, WASH.

Relative humidity (per cent)	April	May	June	July	August	September	Season	Longest period with date
25 or lower	2.0	2.1	3.4	5.2	5.3	2.1	3.6	42; July-August, 1910.
19 or lower	1.5	1.5	2.0	2.9	2.5	1.6	2.3	16; July, 1911.
14 or lower	1.2	1.2	1.3	1.9	1.5	1.3	1.6	8; July, 1911.

TABLE 7.—*The number of days with low relative humidity, within the limits indicated, for each year of the period 1894–1927*

Year	For Seattle					For Portland				
	Per cent of relative humidity, 5 p. m.									
	38–31	30–26	25–20	19	Total	38–31	30–26	25–20	19	Total
1894	12	0	0	0	12	24	0	2	1	36
1895	25	8	5	2	40	27	13	8	7	55
1896	30	6	2	0	38	25	15	6	3	49
1897	10	2	2	0	14	24	15	10	5	54
1898	20	5	9	1	35	17	14	12	7	50
1899	19	7	2	1	29	19	3	3	0	25
1900	16	6	1	1	24	17	7	2	2	28
1901	17	2	3	0	22	12	4	3	1	20
1902	27	3	4	1	35	33	5	0	6	44
1903	14	2	1	1	18	19	10	1	1	31
1904	26	1	3	1	31	37	10	11	6	64
1905	4	5	2	0	11	23	7	7	4	41
1906	28	9	1	1	39	30	10	7	2	49
1907	21	8	1	2	32	23	11	8	5	47
1908	6	1	0	0	7	15	8	0	0	23
1909	14	9	2	0	25	12	11	8	2	33
1910	11	1	0	0	12	25	8	4	0	37
1911	25	5	3	0	33	14	5	7	3	29
1912	18	1	3	2	24	8	5	3	0	16
1913	5	0	0	0	5	14	7	2	0	23
1914	15	2	1	0	18	22	12	3	1	38
1915	12	1	0	0	13	19	6	4	0	29
1916	23	6	3	0	32	23	9	4	3	39
1917	25	5	1	1	32	23	11	4	0	38
1918	23	9	8	0	40	25	21	17	6	60
1919	34	8	1	0	43	27	14	10	5	56
1920	21	3	1	1	26	21	14	5	6	46
1921	17	3	3	0	23	33	6	2	2	43
1922	29	5	3	1	38	20	8	7	1	36
1923	22	5	3	0	30	15	12	2	3	32
1924	25	7	7	2	41	24	11	11	2	48
1925	29	5	2	1	37	7	6	1	2	16
1926	49	7	5	4	65	22	9	12	2	45
1927	19	13	3	0	35	27	9	10	0	46

TABLE 7.—*The number of days with low relative humidity, within the limits indicated, for each year of the period 1894–1927*—Con.

Year	For North Head				For Spokane				For Walla Walla			
	Per cent of relative humidity, 5 p. m.											
	50–41	40–31	30	Total	25–20	19–15	14	Total	25–20	19–15	14	Total
1894	2	1	1	4	23	28	22	73	34	13	4	51
1895	3	0	0	3	30	31	38	99	39	23	3	65
1896	5	3	0	8	31	36	19	86	18	4	2	24
1897	2	1	1	4	32	19	5	56	37	11	2	50
1898	2	0	1	3	51	37	16	104	23	2	1	26
1899	1	2	0	3	35	12	7	54	20	13	8	41
1900	1	0	0	1	40	24	11	75	18	9	0	27
1901	2	0	1	3	29	20	8	57	11	2	0	13
1902	2	0	1	3	47	23	1	71	5	1	0	6
1903	1	0	1	2	47	17	5	69	16	5	1	22
1904	2	0	0	2	42	28	24	94	28	4	0	32
1905	3	1	1	5	35	29	11	75	21	11	3	35
1906	2	0	0	2	48	27	11	86	22	12	2	36
1907	0	1	1	2	41	13	1	55	37	13	2	52
1908	0	0	0	0	40	31	19	90	35	27	16	78
1909	1	0	0	1	40	38	13	91	37	34	27	98
1910	1	1	0	2	42	30	20	92	46	30	33	109
1911	1	0	0	1	42	23	8	73	39	26	29	94
1912	0	3	0	3	34	15	2	51	36	27	8	86*
1913	0	2	1	3	44	19	4	67	42	34	10	86
1914	1	0	0	1	28	35	17	80	27	33	16	76
1915	0	0	0	0	35	23	8	66	42	26	12	80
1916	0	1	1	2	40	25	5	70	35	15	4	54
1917	1	0	0	1	35	28	27	90	33	29	18	80
1918	3	0	0	3	40	44	15	99	50	31	8	89
1919	4	1	0	5	49	32	23	104	46	29	17	92
1920	0	1	0	1	50	26	8	84	34	28	19	81
1921	1	1	0	2	39	18	11	68	51	24	14	89
1922	1	1	3	5	45	33	17	95	38	21	10	69
1923	0	0	0	0	38	28	5	71	37	29	4	70
1924	0	4	1	5	37	47	29	113	33	46	19	98
1925	3	0	3	6	30	44	16	90	25	35	7	67
1926	2	6	1	9	31	40	24	95	34	33	18	85
1927	1	0	1	2	29	16	5	50	33	22	12	67

FOREST-FIRE WEATHER IN CENTRAL MASSACHUSETTS [1]

By PAUL W. STICKEL, Assistant Silviculturist

[Northeastern Forest Experiment Station, United States Forest Service, Amherst, Mass., February 29, 1928]

The forest fire hazard in the Northeast is most acute during two distinct periods in the year: (1) In the spring, from the disappearance of the last snow to the complete foliation of the deciduous trees; (2) in the fall, from the beginning of defoliation until the ground is covered with snow. While the trees and shrubs are in a dormant state, the leaf litter—the principal carrier of fire in the Northeast—is fully exposed to the drying-out action of wind and warm dry weather. Between the spring and fall fire seasons the danger is reduced materially by the influence of the tree foliage upon the leaf litter. In other words, the leaves intercept the sun's rays and diminish wind velocity, thereby lessening the rate of evaporation from the duff, which in turn decreases the fire danger.

The above discussion is equally true for open grassland areas. Until the new crop of green vegetation covers the pastures and meadows in the spring and the snow covers the dead plant remains in the fall, conditions are similar to those which are found during hazardous periods on forested lands.

In the present paper the discussion of the correlation between weather and forest fires will be limited to the conditions in central Massachusetts during the spring of 1927. The fire records are for the following counties: Worcester County, the western half of Middlesex County, and the eastern half of Franklin, Hampshire, and Hampden Counties. The total area of the region is approximately 1,750,000 acres, the greater part of which is included in the so-called white pine region. The meteorological data of the Petersham fire-weather station, maintained jointly by the Northeastern Forest Experiment Station and the Harvard Forest, were used for comparing the weather and the occurrence of fires. At Petersham two observation stations were located in the white pine type—one in a clear-cut area and the other in an adjacent mature stand of northern white pine and eastern hemlock. At each station measurements were taken of duff moisture content of the surface layer and at 1 inch depth, and duff temperature, as well as the regular observations of air temperature, relative humidity, evaporation, wind velocity, and rainfall. Atmometers (using the Livingston porous bulbs and Nichols mountings) placed at the level of the leaf litter were employed in securing evaporation data. Special mention should be made of the fact that the three-cup Robinson anemometers were placed only 3½ feet above the ground. Four observations were taken daily: at 8 a. m., 11 a. m., 2 p. m., and 5 p. m. In the tables and graphs which are presented herewith the 2 p. m. records of the station in the clear-cut area are used. These records are chosen (1) because they represent the maximum degree of hazard; (2) because the average daily minimum relative humidity and average daily maxima of air temperature, evaporation, solar radiation, and wind movement occur around 2 p. m. These are all conditions which tend to create a low duff moisture content and consequently a high fire hazard.

Weather conditions during the early part of 1927 were especially favorable for the inception and spread of forest fires. A mild open winter with moderate snowfall was followed by a very dry, warm spring. The transition began early in March and by the end of that month was

[1] The author wishes to thank Mr. A. W. Gottlieb for his assistance in collecting the data at the Petersham, Mass., fire-weather station maintained jointly with the Harvard Forest.

practically complete. Summer heat was recorded on several days during the latter part of March, with the result that what little snow was present disappeared rapidly and early. To sum up, almost six weeks elapsed (March 15 to April 30) from the time when the ground was last covered with snow to the appearance of the green crown cover and the spring rains.

The effect of the dry, warm spring weather upon the leaf litter is reflected directly in the forest fire records. Several fires were reported in March, but the maximum

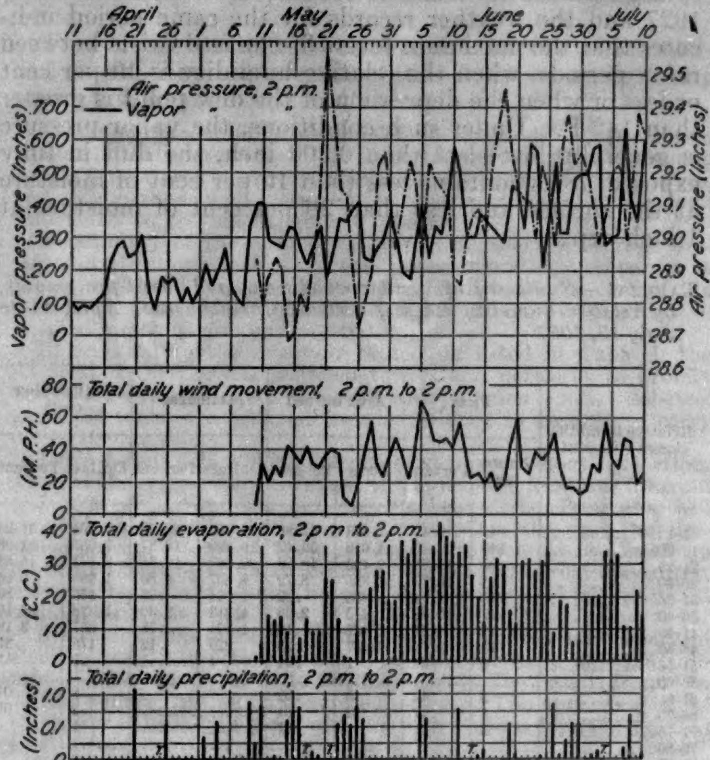


FIG. 1.—Graphs of vapor pressure, air pressure, total daily wind movement, total daily evaporation, and total daily precipitation at Petersham, Mass., April 11-July 10, 1927

number occurred during April. The largest number of and most disastrous fires occurred during the period when fire-weather records were taken. Therefore, while it is true that the entire spring fire season can not be considered, the records taken are representative.

Figures 1 and 2 are graphical presentations of the principal meteorological factors, in addition to duff moisture content of the surface duff layer, duff moisture content at 1 inch depth, and area burned. An inspection of these graphs indicates that of all the climatic factors relative humidity appears to be the best single indication of forest fire hazard, since the peaks of area burned occur with the low records of relative humidity. However, it is the cumulative effect of dry weather—from the end of one rainy period to the beginning of another—which results in the leaf litter becoming dry enough to burn readily. A single reading of relative humidity does not always give a true picture of the hazard. In order to evaluate the probable effect of the moisture content of the air upon that of the duff, we must first know the present duff moisture content. Therefore, the duff hygrometer is indispensable in any system of fire-weather forecasting. A comparison of the curves of relative humidity and duff moisture content indicates that an excellent correlation exists between them, when rainy periods are excluded. This is more readily observed in Table 1, where weather conditions and forest fire records are summarized by relative humidity classes.

Of all the major forest types in the Northeast, the white pine type is inherently the most hazardous. Its leaf litter is highly inflammable because of the resin content. The size and form of pine needles produce a duff with practically no matting but with a great deal of porosity, so that the run-off after rainfall is extremely rapid. The site conditions are of little value in reducing the hazard. White pine in New England is confined generally to the poorer soil types—those composed chiefly of sand. Hence, the rapidity with which the duff dries out is not surprising. Daily rainfalls of one-tenth of an inch or less do not keep the duff above the danger zone. Even with greater amounts of precipitation, the duff moisture content does not remain above 10 per cent for long unless the rains occur at short intervals.

Two additional factors are valuable aids in fire-weather research. The first is the difference between the current air temperature and the dew point temperature, which has been termed the depression of the dew point by Lindgren.[2] The greater the divergence between these

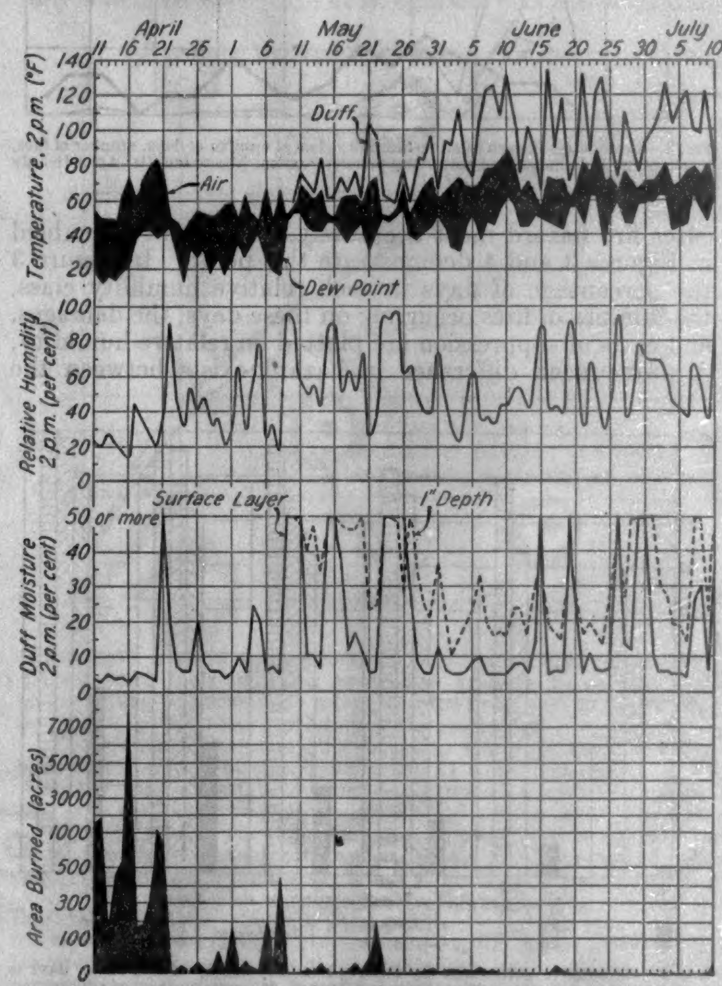


FIG. 2.—Meteorological conditions and forest fires in central Massachusetts, April 11-July 10, 1927. (Weather records taken at Petersham.) Graph 1: 2 p. m. duff, air, and dew-point temperatures. Graph 2: 2 p. m. relative humidities. Graph 3: 2 p. m. duff—moisture percentages at surface layer and at 1 inch depth. Graph 4: Daily area burned

two curves, the lower is the moisture content of both the atmosphere and the duff, and the greater is the fire hazard. When the depression of the dew point exceeds 14° F., hazardous conditions exist. This is similar to the danger point established by Lindgren for the Adirondack Mountain region. Vapor pressure as an aid in forest

[2] Lindgren, G. S. Fire Weather in the Adirondacks. Bul. Amer. Met Soc. vol. 7, No. 2, 1926, pp. 30-32.

fire-weather forecasts has been advocated by McCarthy.[3] In the present investigation also vapor pressure has been found to indicate the trend of fire weather, since the days of greater danger were accompanied by low vapor pressures.

As has been mentioned already, relative humidity seems to be the single meteorological factor which indicates fire hazard most accurately. The data assembled in Figures 3 and 4 demonstrate this point. In Figure 3 the percentage of days in each relative humidity class, the number of fires occurring on these days, the damages, and costs of suppression are plotted on relative humidity. A pronounced difference in hazard exists between the days when the relative humidity was 40 per cent or less and the days when it was greater than 40 per cent. When the relative humidity exceeded 40 per cent, the fires were few and small, and the damages and suppression costs were negligible. Figures on a cumulative basis (Fig. 4), 41.7 per cent of the spring days had relative humidities of between 14 and 40 per cent. On these days 90.7 per cent of the fires occurred, burning over 98.5 per cent of the total area burned, causing 99.1 per cent of the total damages, and amounting to 95.8 per cent of the entire suppression costs. While hazardous conditions do not necessarily produce fires, yet had greater precaution been exercised on these days (less than half the total days in spring) practically all the fires might have been eliminated.

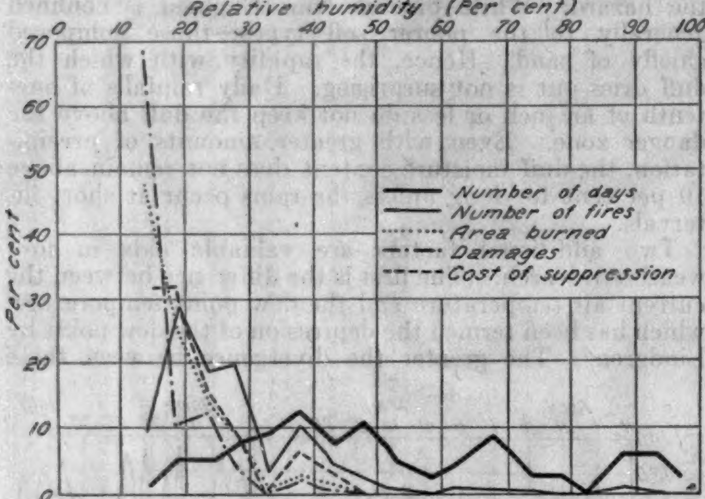


FIG. 3.—Percentages in each relative-humidity class of number of days, number of fires, area burned, damages, and cost of suppression, central Massachusetts, April 11–July 10, 1927

FIG. 4.—Cumulative percentages by relative-humidity classes of number of days in each humidity class, number of fires, area burned, damages, and cost of suppression, central Massachusetts, April 11–July 10, 1927

To summarize briefly, a graphical comparison of the spring forest fire records for central Massachusetts during 1927 and the weather records for the same period indicates that the maximum forest fire hazard exists between rainy periods, when the relative humidity is 40 per cent or less or when the depression of the dew point is greater than 14° F. Under such conditions, the vapor pressure is generally low—less than 0.300 inch, the duff in fully exposed areas contains less than 10 per cent of moisture at the surface and less than 20 per cent of moisture at 1 inch depth.

TABLE 1.—*Summary of weather conditions and forest-fire records, by relative humidity classes, central Massachusetts, April 11 to July 10, 1927*

Relative humidity classes (per cent)	Fires		Area burned		Damages		Suppression costs	
	Number	Per cent	Acres	Per cent	Dollars	Per cent	Dollars	Per cent
11–15	45	9.47	7,643	47.86	125,960	68.70	7,004	31.96
16–20	140	29.47	4,059	25.42	19,890	10.87	7,007	31.98
21–25	90	18.95	2,123	13.29	22,667	12.36	3,477	15.88
26–30	94	19.79	1,395	8.72	8,807	4.80	1,985	9.06
31–35	13	2.74	36	.22	104	.06	176	.80
36–40	49	10.32	473	2.96	4,213	2.30	1,338	6.10
41–45	20	4.21	186	1.16	1,424	.78	697	3.18
46–50	13	2.74	37	.23	229	.12	178	.81
51–55	4	.84	2	.01	1		25	.11
56–60								
61–65	2	.42	3	.02	2		8	.04
66–70	1	.21	2	.01			2	.01
71–75	1	.21	1	.01			1	
76–80								
81–85								
86–90	3	.63	13	.08	25	.01	16	.07
91–95								
96–100								
Total	475	100.00	15,970	100.00	183,372	100.00	21,914	100.00

Relative humidity classes (per cent)	Average 2 p. m. observations within humidity classes									
	Dry bulb	Dew point	Relative humidity	Air pressure	Vapor pressure	Duff moisture: Surface	Duff moisture: 1" depth	Duff temperature	Evaporation [1]	Wind velocity [2]
	° F.	° F.	Per cent	Inches mercury	Inches mercury	Per cent	Per cent	° F.	Cubic centimeters daily	Miles daily
11–15	75	50	14		0.124	3				
16–20	64	46	19		.120	4				
21–25	62	45	24	29.40	.135	5	19	108	29.6	29.7
26–30	66	49	28	29.17	.185	11	12	110	33.5	34.6
31–35	67	51	33	29.22	.235	7	21	109	28.6	34.6
36–40	68	54	38	29.24	.279	7	19	109	28.8	29.1
41–45	72	58	43	29.12	.345	7	26	100	29.5	33.5
46–50	61	51	48	28.95	.275	13	32	85	19.5	33.6
51–55	64	55	52	28.97	.337	12	38	86	23.2	43.6
56–60	74	65	58	28.88	.408	28	38	102	12.8	16.9
61–65	62	54	62	28.80	.317	30	37	68	12.4	43.0
66–70	68	61	68	29.13	.418	18	36	93	17.2	30.6
71–75	58	54	74	29.00	.354	32	44	61	13.9	26.6
76–80	56	52	78	29.22	.374	35	[3] 50	75	5.8	15.3
81–85										
86–90	55	52	88	28.92	.382	41	46	66	8.5	27.7
91–95	56	55	94	29.08	.428	[3] 50	48	64	7.5	37.2
96–100	52	51	97	28.89	.361	[3] 50	49	58	.7	5.4

[1] At same level as duff. [2] Atmometers placed 3½ feet above ground.

[3] McCarthy, E. F. Forest Fire Weather in the Southern Appalachians. MONTHLY WEATHER REVIEW, April, 1923, 51: 182–185.

PROTECTING OIL RESERVOIRS AGAINST LIGHTNING[1]

By MARION E. DICE

During April, 1926, lightning caused the destruction of 9,000,000 barrels of oil storage facilities in California, with an economic loss second in the history of the State only to that of the San Francisco disaster of 1906.

The catastrophe awakened the petroleum industry to the hazards of above-ground storage and set in motion a number of engineering activities which have led to the general adoption of protective measures throughout the State.

This article is intended to report a survey of methods and to describe the present state of the art of lightning protection as practiced in California. * * *

Lightning protection systems.—Three methods of protection against lightning are in use: (1) Towers which function as lightning rods, (2) networks to prevent sparks caused by induced discharges, and (3) barbed wire designed to discharge the thundercloud sufficiently to prevent dangerous voltages.

A summary of the number of barrels of reservoir storage protected by various means by the major operating companies is given in Table I (not reproduced), which lists 95 per cent of the storage in the State. The remaining 5 per cent is probably in isolated locations and unprotected.

In addition to the reservoir protection listed in Table I, the Associated Oil Co. has installed towers and networks to protect 286,000 barrels of steel tankage with wooden roofs. All-steel gas-tight tanks are believed from experience to be able to carry direct strokes safely.

Table I shows 25,300,000 barrels of storage without protection. Most of these reservoirs are small and in isolated locations far from populous centers and are used only for heavy oil. Protection will probably be installed for some of them before the next thunderstorm season. Some of these reservoirs are emergency containers made by throwing an earth dam across a canyon in rolling country, with no floor covering and no roof. They are used for heavy oil containing much sand.

Dimensions and locations of towers.—The towers are usually of steel lattice construction of the type used for radio antenna supports. They are from 75 to 200 feet high. The base is from 4 to 24 feet square, resting on concrete footings. The upper portion of the tower is usually a piece of pipe, with various kinds of pointed tips.

In some cases the towers are connected by cables fastened to the lattice work below the pipe extensions. One company grounds the center of each cable span by a copper down lead, and places a 7-foot copper rod at the junction of the cable and the down lead, with 3 feet of its length projecting above the cable. This is intended to localize corona and, by forming an ionized path, aid in directing the stroke to the system.

Most of the towers were located in accordance with the experimental findings of F. W. Peek, jr., of the Pittsburgh laboratories of the General Electric Co. ("Lightning; a study of lightning rods and cages, with special reference to the protection of oil tanks," Journal A. I. E. E., 45, 1246, December, 1926). He originally proposed an empirical law that a lightning road would protect a radius equal to four times its height, and five companies built towers on this basis. Later laboratory work, however, brought about a modification of the law and led to an increase in the height of many towers. One company has increased the height of its towers from 150 feet to 200 feet. The new basis, shown in the accompanying chart (Fig. 1), gives the protected radius (in terms of rod heights) as a function of the ratio between the cloud height and the rod height.

Most of the reservoir farm rod layouts were tested by means of scale models in the Pittsfield laboratories, and final installations were made on these results rather than on empirical data from ideal cases. A model of the Southern Pacific Co.'s 3,000,000-barrel reservoir at Tracy was subjected to 2,300 discharges of artificial lightning without a single stroke to the reservoir.

The General Petroleum Corporation made an elaborate series of tests with models at the California Institute of Technology, through the cooperation of Prof. R. W. Sorensen, before drawing up its construction program. The layouts adopted were tested again by Mr. Peek with results in close agreement with those of Pasadena.

The Pan American Petroleum Co. carried out its own laboratory work along somewhat different lines as mentioned later.

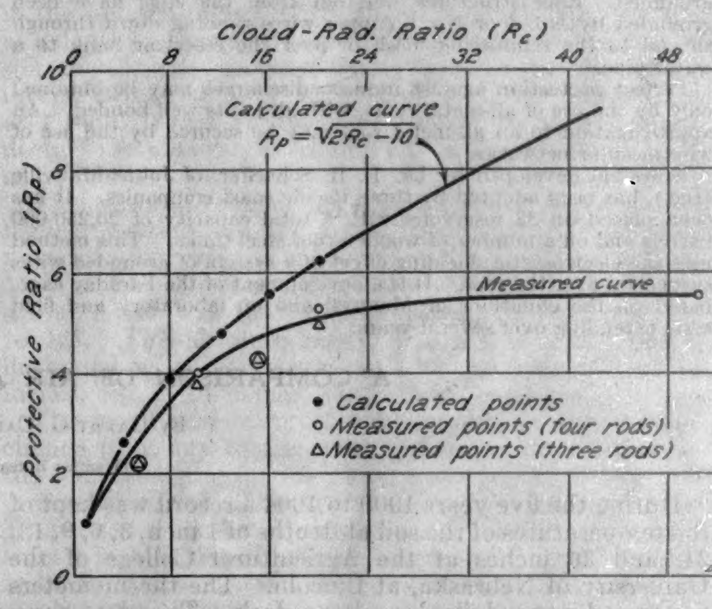
[1] Abstracted from Engineering News-Record of July 7, 1927.

Thundercloud heights.—In order to use Mr. Peek's protective ratio chart, it is necessary to know the approximate cloud height. Weather Bureau observers have measured the altitude at which kites and pilot balloons disappeared into the bases of clouds on 5,500 occasions east of the Rocky Mountains. Thunderclouds were measured in 700 cases.

The lowest thundercloud base measured was 820 feet above the earth. The altitude of maximum frequency was 3,120 feet. Only 6.3 per cent of the cloud bases were below 2,000 feet; 69.6 per cent were between 2,000 and 6,000 feet; and 24.1 per cent were above 6,000 feet.

The height of thundercloud bases varies inversely with the humidity of the rising air. Therefore, since the average humidity on the Pacific coast is lower than in the Central and Eastern States, the range of altitudes given is too low for the Pacific coast. Only in exceptional cases will thundercloud condensation occur below 2,000 feet in California, and 1,000 feet may be set as an absolute minimum.

Ground connections.—The importance of good ground connections is recognized by all companies. Two have drilled a well to permanent water at each tower. Another has wells at most towers and connects the others to pipe lines. Two use pipe grounds driven to moist soil or kept moist by water from within the pipes.



Two make ground connections to pipe lines only. Most companies bond their lightning protection systems to several earth connections; to permanent water, to pipe lines, and in many cases to buried copper rings surrounding the reservoirs.

The General Petroleum Corporation connects each tower to permanent water through a well from 31 to 60 feet deep. A No. 4 copper wire is used, being connected to each leg of the tower, to the pipe casing of the well, and to a weight hung below the water level in the pipe. The pipe is set in steel punchings to increase the area of metal in contact with water and earth. Each tower is also connected to the 3-inch water line surrounding the nearest reservoir. The water line is connected to the reinforcing mesh of the concrete by No. 4 wire at several points around the rim.

Where cables are used between towers, the center of each span is grounded (to decrease the inductance) by a ½-inch flexible copper sash cord falling from the cable, anchored to a pipe post just outside the fire wall, and connected to the water line around the reservoir. This system provides metallic paths for ground charges from both their possible levels and the tower system, recognizing that the ground charge may reside at the level of permanent water or at the surface, depending on the conductivity of the earth.

Measurements of resistance indicate values less than 10 ohms through earth paths between separate wells or between wells and pipe lines, and less than 1 ohm through all metallic paths of the system.

Most companies have made no special provision for grounding the reinforcing steel of the reservoirs. The concrete floors are of such large area that good ground contact is assured. Many

resistance measurements have been made between the mesh and near-by water pipes. So far as is known, none of the resistances exceeded 10 ohms; most of them were lower.

Network protection.—It is well known that fires may be started by lightning without occurrence of direct hits. A cloud-to-cloud discharge or a stroke to earth at some distance from an oil tank may cause sparks between isolated metal parts due to the release of the bound electrostatic charge.

For example, a thundercloud may have its charge gradually increased, by the breaking up of water drops falling through upward currents of air (Simpson, G. C., "On the electricity of rain and its origin in thunderstorms," Phil. Trans. Roy. Soc. A 209, 379, 1909. See also Proc. Roy. Soc. for April, 1927), or whatever process takes place, until the voltage approaches spark over. During the charging-up period, a charge of opposite sign builds up by induction on the earth below. At spark over (whether to another cloud, to another part of the same cloud, or to earth) the induced charge on the earth is released. It spreads out in all directions to get back to normal density. Sparks can occur during this rush only between isolated conductors or conductors in poor contact. A reservoir roof may have isolated metallic structures such as gauging wells, swing-pipe winch boxes, ventilators, etc., or it may have a combination of metal nailing strips, nails, and patches of condensate below the roofs with dangerous spark gaps.

All reservoir owners have inspected their reservoirs and have taken precautions against such conditions wherever possible. Metallic equipment and pipes have been interconnected and grounded. Roof structures well out from the edge have been grounded by No. 4 or No. 6 copper wires running down through the oil to the reinforcing mesh or over the reservoir bank to a water pipe.

Perfect protection against induced discharges may be obtained only by the use of all-metal roofs, with all joints well bonded. An approximation to an all-metal roof may be secured by the use of wire mesh or networks.

A system developed by Dr. E. R. Schaeffer, of Johns-Manville (Inc.), has been adopted by three Pacific coast companies. It has been placed on 32 reservoirs with a total capacity of 26,250,000 barrels and on a number of wooden-roof steel tanks. This method uses the electrostatic shielding effect of a system of grounded wires suspended over the roof. It is a development of the Faraday cage, based on the equations of Maxwell and on laboratory and field tests extending over several years.

The network used on reservoir roofs consists of No. 12 galvanized telephone wires, parallel, spaced 4 feet apart and 6 to 12 feet above the roof. The wires are supported by a ⅜-inch peripheral cable carried on posts around the reservoir and by another cable crossing the roof on posts. Where the strength of the roof is not sufficient to carry the additional load, the center cable is suspended from a catenary. The network projects 16 feet beyond the rim at all points.

The network used on wooden roofs of steel tanks consists of an umbrella type grid supported by a single post 9 feet above the peak of the roof and by galvanized brackets spaced 15 feet apart around the rim. No. 12 galvanized wires radiate from the center post to the brackets with supplementary wires filling the wide gaps near the periphery so that the maximum spacing of wires is 5 feet.

On both reservoir and tank grids all wires are carefully bonded to the peripheral cable or tank brackets. The cables are grounded through their radial guys to water pipes or to a copper wire buried 12 inches and surrounding the reservoir.

The value of the network is due to the fact that it carries the induced charge, keeping if off the roof and affording good metallic paths to ground for its return after release. The percentage of the induced charge removed from the roof to the network is a function of the diameter and spacing of the wires, their height above the roof, and the cloud height. The arrangement adopted is one whichi s claimed to be an economical approximation of an all-metal roof.

Prevention of lightning voltages.—One company has adopted a system which it is claimed will prevent the formation of lightning voltages and therefore prevent both direct and induced discharges. The system consists of barbed wire strung on steel towers 80 to 100 feet high around each reservoir for the purpose of dissipating, by corona discharge, any induced charges in the area. The inventor, John M. Cage, of Los Angeles, claims that the charge of a thundercloud may be neutralized in this manner or kept below the sparking value. This system, which is described in detail in current petroleum journals (Wilcox, E. H., "Lightning protection system adopted to prevent, not guide, the stroke," Nat. Pet News, March 9, 1927, p. 77; same author, "The cage system of lightning protection," Oil Age, March, 1927, p. 18), has been installed on six reservoirs with a total capacity of 12,500,000 barrels. Included in this group is the largest oil reservoir in the world. The reservoirs are used for fuel oil only.

A COMPARISON OF AIR AND SOIL TEMPERATURES

By HARRY G. CARTER, Meteorologist

[Weather Bureau, Lincoln, Nebr.]

During the five years 1900 to 1904 a record was kept of the temperatures of the soil at depths of 1 inch, 3, 6, 9, 12, 24, and 36 inches at the Agricultural College of the University of Nebraska, at Lincoln. The thermometers were read once daily, at about dark. The data were tabulated and comparisons made with air temperatures as recorded by the United States Weather Bureau at the regular 6:45 p. m. observation at the city campus of the university, about 3 miles to the southwest.

The thermometers used in obtaining soil temperatures were standard soil thermometers. The scales from which the readings were made were made above ground so that the thermometers were not disturbed when read. The tube of each was inclosed in a closely fitting wooden cylinder which prevented air from passing down around it and also prevented the mercury in the tube from being affected by the surrounding soil. The bulb at the bottom was uncovered. The surface of the ground above the thermometer bulbs was kept free of grass and weeds over a rod square. The readings were made daily just before dark.

It was found that the temperature, for the year as a whole, averaged 54.9° in the air, and 58.2° in the soil at a depth of 1 inch. There was a decrease in annual temperature of the soil from 1 inch down to 12 inches, where it averaged 51.5°, then a slight increase down to 24 inches, where it averaged 52.2°. The average at 36 inches was the same as at 24 inches. For the whole year the temperature of the soil at a depth somewhere between 6 and 9 inches averaged the same as the temperature of the air.

Table 1 gives the mean monthly and annual temperatures of the air and of the soil at the various depths at which readings were made.

TABLE 1.—*Mean monthly and annual temperature of the air and of the soil at depths of 1 inch, 3, 6, 9, 12, 24, and 36 inches, at Lincoln, Nebr., for the 5 years 1900 to 1904, inclusive, as determined by considering one daily reading of the thermometers*

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Air	29.2	25.1	42.8	56.5	67.8	75.6	82.7	79.1	68.4	60.7	42.5	28.8	54.9
Soil:													
1 inch	30.0	28.2	42.4	58.6	74.5	82.3	90.8	85.6	72.0	60.0	43.5	31.0	58.2
3 inches	30.0	28.7	41.1	59.3	72.1	81.2	88.6	85.3	72.9	61.4	44.3	31.6	58.0
6 inches	29.6	28.0	37.9	54.5	68.7	77.5	83.6	82.0	71.0	60.2	44.1	31.9	55.8
9 inches	30.0	28.4	35.7	50.8	64.4	73.0	79.4	77.9	70.5	59.0	44.3	33.4	53.9
12 inches	31.4	29.3	35.0	48.2	60.8	69.5	75.8	75.0	66.6	58.4	45.1	34.8	51.5
24 inches	35.1	32.9	34.7	44.8	56.5	64.2	70.8	71.6	66.9	59.7	49.5	39.5	52.2
36 inches	38.1	35.3	35.7	43.0	53.2	61.1	67.5	69.4	66.7	60.7	52.1	43.2	52.2

A study of Table 1 shows that the lowest mean monthly temperatures in the soil were recorded at all depths during February, and from 1 inch down to 12 inches the highest monthly means were recorded during July. At 24 and 36 inches there was a slight lag, the highest monthly means being recorded during August instead of July.

Air temperatures averaged lower than the temperature of the soil at all depths during the winter months and were higher than in the soil below 9 inches during spring, summer, and early autumn. At a depth of 1 inch the soil averaged warmer than the air, except during March and October. At 24 inches monthly means averaged above freezing throughout the year, although readings below 32° were observed several times.

During late fall and winter the temperature of the air averaged lower than that of the soil at a depth of 36 inches and was higher from March to September. During October there was but little difference in monthly means of the soil at the different depths, and the average of the soil was not far from the mean air temperature. The greatest difference between the monthly means of the air and that of the soil at 36 inches was in July, when the air averaged 15° warmer. In December, however, the soil at 36 inches averaged 14° warmer than the air.

In Table 2 are presented the highest and lowest temperatures of the air and of the soil at depths of 1 inch, 3, 6, 9, 12, 24, and 36 inches for each year of the five years 1900 to 1904, inclusive. These values were determined by considering the highest and the lowest reading each month as recorded from one daily reading of the thermometers.

TABLE 2.—*Highest and lowest temperatures of the air and of the soil at depths of 1 inch, 3, 6, 9, 12, 24, and 36 inches for each year for 5 years, 1900 to 1904, inclusive, at Lincoln, Nebr., as determined by considering the highest and the lowest readings each month as recorded from one daily reading of the thermometers*

	1900		1901		1902		1903		1904		For 5 years	
	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest
Air	94	2	102	−8	91	0	95	0	91	−6	102	−8
Soil:												
1 inch	102	19	120	12	91	20	-----	-----	95	20	120	12
3 inches	100	21	110	16	90	22	94	21	96	20	110	16
6 inches	93	22	102	19	87	25	89	23	90	22	102	19
9 inches	89	26	92	25	86	26	85	23	84	23	92	23
12 inches	81	28	86	27	78	28	80	24	79	23	86	23
24 inches	75	33	77	33	73	33	73	32	72	29	77	29
36 inches	71	35	73	36	76	35	70	34	69	32	76	32

It will be noted that the highest air temperature recorded was 102°. Readings as high as this, or higher, were recorded as deep in the soil as 6 inches, 120° being recorded at a depth of 1 inch; 110° at 3 inches, and 102° at 6 inches.[1] Below 6 inches the highest temperatures recorded was not as high as that recorded in the air, 92° being the highest observed at 9 inches; 86° at 12 inches; 77° at 24 inches; and 76° at 36 inches. These high readings were all made during July with the exception of the reading at 36 inches, which occurred in September.

The lowest air temperature recorded during the five years was 8° below zero, while at a depth of 1 inch in the soil 12° was the lowest observed; at 3 inches, 16° was the lowest; at 6 inches, 19°; at 9 inches, 23°; at 12 inches, 23°; at 24 inches, 29°, and at 36 inches, 32°.

At a depth of 12 inches in the soil the last freezing temperature in spring was recorded in March and the first in autumn was recorded in December. At 24 inches freezing temperatures were recorded in one year in January; in two years in February; and in two years in March. At 36 inches freezing temperatures were recorded in only one year out of the five and then during only one period, from February 21 to March 7, 1904, when the thermometer read 32° each day for 16 consecutive days.

When unusually high or low temperatures were recorded in the air they would be recorded on the same day in the soil down to a depth of 6 inches. At 9 and 12 inches they were frequently recorded 24 to 48 hours later than in the air, and at 24 and 36 inches there would be no apparent indication of unusually high or low air temperatures.

The mean annual range, or the difference between the highest and the lowest readings observed each year, averaged for the five years, was greater in the air than in the soil, averaging 97° in the air and 84.2° in the soil at a depth of 1 inch. There was a decrease with increased soil depth, the decrease being greater in the upper layers, averaging 54.8° at 12 inches, or 29° lower than at 1 inch. From 12 inches downward to 36 inches the decrease was slower, averaging 42° at 24 inches and 37.4° at 36 inches.

The absolute range, or the difference between the highest reading and the lowest reading during the five years of observations, was 110° in the air, ranging from 102° to 8° below zero, while the absolute range in the soil at 1 inch was 108°, temperatures ranging from 120° to 12°. The absolute range, like the monthly range, decreased with increase in soil depth, being 63° at 12 inches, 48° at 24 inches, and 44° at 36 inches.

The mean variability of temperature, or the average change from day to day, was greater in the air than in the soil, averaging for the whole year roughly 50 per cent greater in the air than in the soil at a depth of 1 inch. There was a gradual decrease in variability of the soil from 1 inch, where it averaged between 4° and 5°, down to 36 inches, where it averaged less than half a degree.

Air temperatures showed the greatest variability in spring, early summer and early winter, and least in late summer and late winter, averaging nearly twice as great in April as in August.

Temperatures of the soil at all depths from 1 inch down to 36 inches showed the greatest variability in early summer and the least in winter. At 1 inch, daily changes in summer occasionally exceeded 10° and averaged about seven times greater than in winter. Changes from day to day were less frequent and smaller the deeper the soil, and at 36 inches the temperature was the same from day to day for a week or so at a time, and when changes did occur they seldom exceeded 1°.

[1] July, 1901, was an exceptionally warm month, the mean temperature averaging 8.6° above the normal.—*Editor.*

DIURNAL VARIATION OF RAINFALL AT SAN JUAN, P. R.[1]

C. L. Ray

[Weather Bureau Office, San Juan, Porto Rico]

In the following notes are given the hourly frequencies of rainfall, based upon the 23-year record (1905 to 1927) at San Juan, P. R. These are shown for the several months and year. The results are offered not so much with the idea of adding to the subject as covered in studies of Dr. O. L. Fassig[2] as to incorporate into the latter data the records of the additional 10 years that are now available. San Juan is in some respects distinguished by an oceanic as well as tropical climate. This is particu-

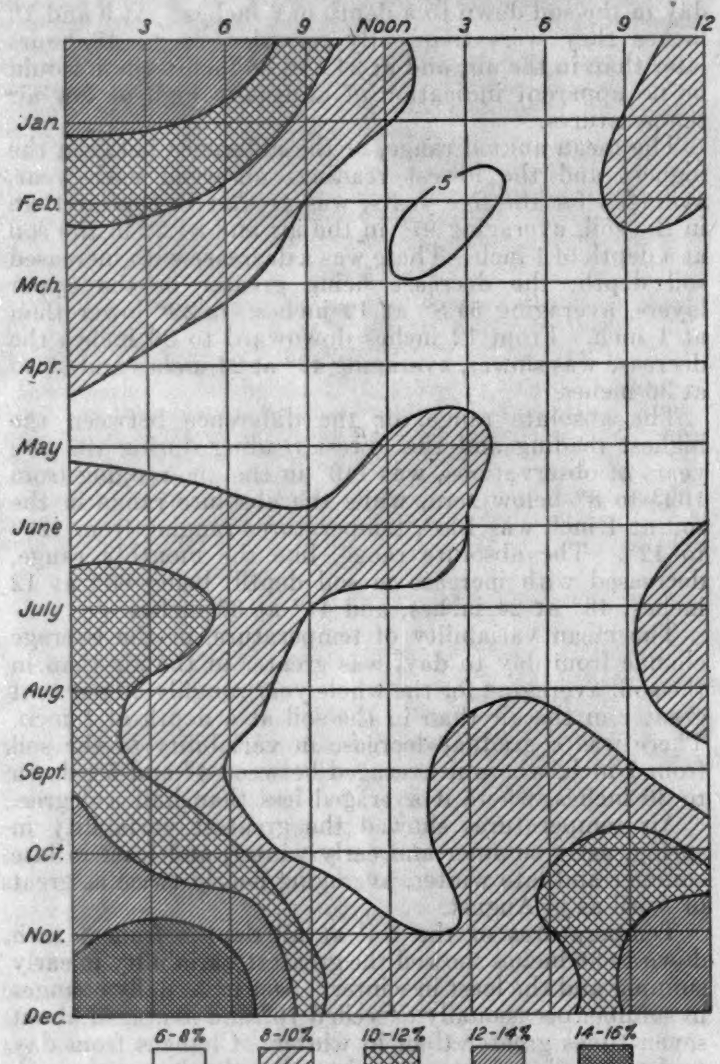


Fig. 1.—Three-hour rainfall frequency (1905-1927), San Juan, P. R.

larly noted in the predominance of night rainfall frequency. The same has been found to be true also of Honolulu, Hawaii, as shown in the paper of Loveridge.[3] In Table 1, in the present paper, is given the hourly frequencies at San Juan and in Figure 1 is given a graph of these results. As will be noted, there is a maximum night frequency in January, February and March, April, July, August, November, and December, with secondary maxima in May, June, September, and October. In these latter months, which break the otherwise continuous night maximum frequency throughout the year, there is a primary maximum in the afternoon hours, also characterized by a greater intensity per shower.

In the month of December occurs the maximum frequency of the year (17) for a single hour, from 4 to 5 a. m.

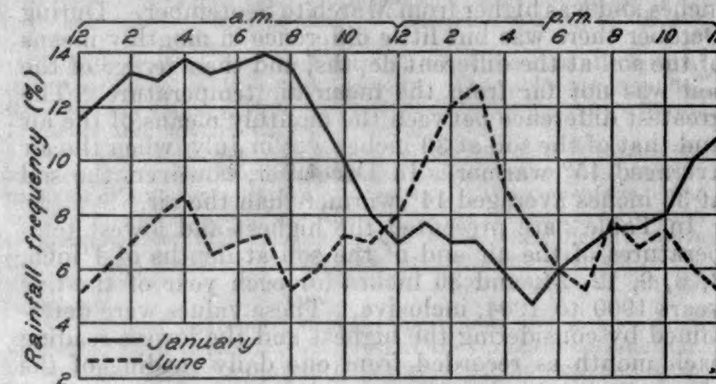


Fig. 2.—Hourly frequency of rainfall, San Juan, P. R., 1905-1927

with a secondary maximum of 16 per cent from 1 to 2 a. m. The least frequency for the month is 5.9 per cent, occurring from 4 to 5 p. m. From these figures it may be said that there is a three times greater chance, during December that rain will fall between 2 and 5 a. m. than from 2 to 5 p. m. The least frequency for the year is 2.8 per cent from 11 to 12 noon in March.

In Figure 2 is shown the January and June hourly frequency and in Figure 3 the annual hourly frequency and hourly intensity. The maximum intensity occurs in

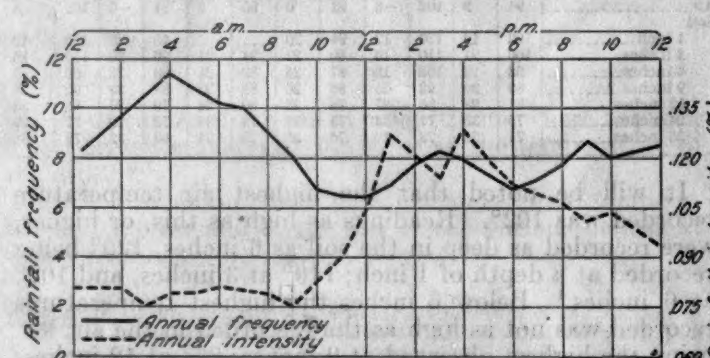


Fig. 3.—Annual hourly frequency and intensity of rainfall, San Juan, P. R., 1905-1927

the period from 1 to 4 p. m. as compared with the maximum frequency from 2 to 5 a. m. A comparison of the frequency and depth of rainfall in Tables 2 and 3 shows, however, a rather close agreement between the two, in certain months. For example, in the January, February, December period there is a maximum frequency and maximum accumulated amount of rain in the six hours 1 to 6 a. m., with each of the other three six-hour periods in agreeing order, the least frequency and least amount occurring from 12 noon to 6 p. m. From April to October, on the other hand, there is a shift in the maximum amount of rainfall to the period from noon to 6 p. m. which is not in every instance balanced by a similar change in frequency. A better comparison is possibly obtained by taking two 12-hour periods, from 6 p. m. to 6 a. m. and from 6 a. m. to 6 p. m. In this arrangement we have the six months, January, February, March, June, November and December, in agreement, with both

[1] Cf. Fassig. Tropical Rains, Their Duration, Frequency and Intensity. Monthly Weather Review, vol. 44, June, 1916, p. 329, etc.
[2] Monthly Weather Review, 52: 584.
[3] Loveridge. Diurnal Variation of Precipitation at Honolulu. Monthly Weather Review, vol. 54, December, 1924, p. 585, etc.

frequency and amount reaching a maximum in the night hours with the exception of June, during which month both fall in the day period. In April both frequency and

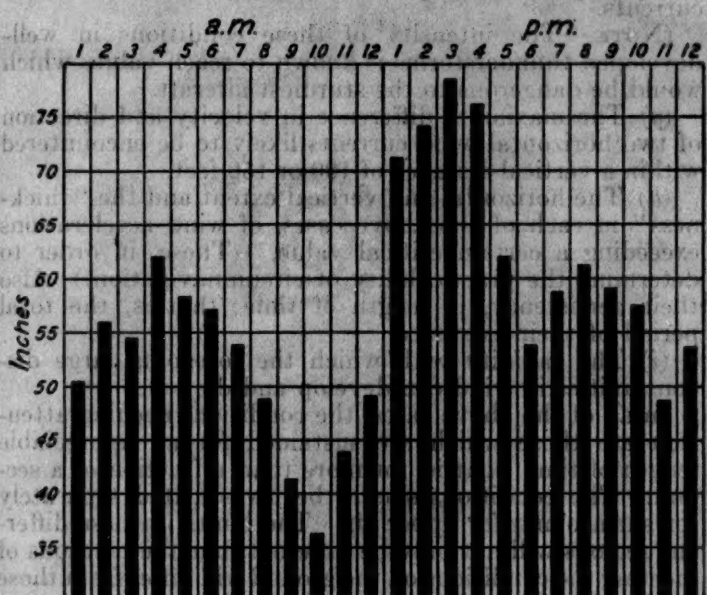


FIG. 4.—Annual accumulated hourly rainfall, San Juan, P. R., for 23 years, 1905–1927, inclusive

amount are about equally divided between night and day. In May there is a 50–50 frequency but 14 per cent greater amount falling in daytime hours. In July, August, and

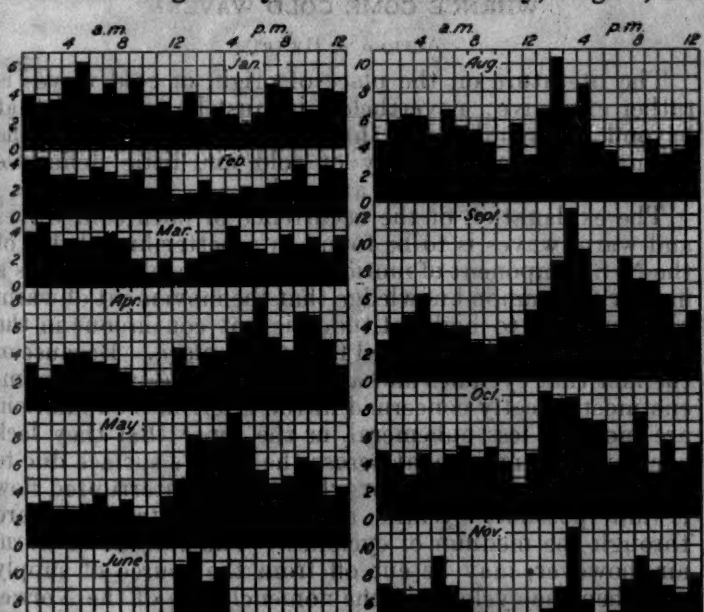


FIG. 5.—Accumulated amounts of rainfall, San Juan, P. R., for 23-year period, 1905-1927, inclusive

September the 12-hour day period receives from 8 to 12 per cent greater amounts of precipitation than night hours, while the frequency is divided practically 50-50 between night and day. In October both frequency and amount are almost equally divided.

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Accumulated amounts for the 23 years as occurring for each hour are shown in Figure 4. A maximum of 79.15 inches has been recorded for the hour 2 to 3 p. m. and 75.59 inches from 3 to 4 p. m. while the least accumulated amount was 36.19 inches from 9 to 10 a. m. In Figure 5 the monthly accumulated amounts are shown to agree with the annual trend, particularly from April through November, while in the winter months a shift in the maximum amounts from afternoon to early morning hours occurs.

An interesting comparison is afforded in the hourly frequencies of the rainfall at Honolulu. In the annual frequency for that station there occurs a small secondary maximum at 8 p. m., comparing with a similar secondary maximum at 9 p. m. at San Juan. The frequencies at Honolulu, however, show a much lower afternoon percentage than occurs at the Caribbean station, where during several months of the year are recorded maximum frequencies for the 24 hours in the afternoon period. The monthly proportion between maximum and minimum frequency is as high as 8 to 1 at Honolulu, but does not quite attain a 4 to 1 range in the most extreme instance at San Juan, and as a rule does not exceed a 2 to 1 variation. The predominance of the maximum night frequency is pronounced at both stations, however.

TABLE 1.—*Hourly frequency of precipitation, San Juan, P. R. (1905–1927)*

	A. M.—hour ending at—											
	1	2	3	4	5	6	7	8	9	10	11	12
January	12.6	13.7	13.0	*14.1*	13.7	13.9	14.0	13.9	10.8	8.6	7.7	7.2
February	9.2	10.8	10.3	10.7	*11.8*	10.8	9.8	11.2	11.2	7.1	6.5	5.1
March	8.6	10.0	9.1	9.1	10.6	10.5	*10.7*	10.6	8.0	4.3	4.2	2.8
April	6.2	6.8	8.0	*9.0*	7.4	7.8	7.5	6.8	5.8	4.6	5.0	5.7
May	4.2	6.6	8.3	8.1	8.1	6.9	7.5	6.6	6.7	6.1	4.9	6.9
June	6.1	7.1	8.4	8.3	6.2	6.7	7.4	4.6	5.4	7.7	7.0	8.1
July	9.5	10.0	10.7	*11.4*	11.1	9.5	10.0	8.6	9.1	7.3	7.3	8.1
August	8.5	10.8	*14.0*	12.6	11.4	11.3	10.0	9.0	7.2	6.1	7.7	6.1
September	8.8	8.1	8.1	9.7	9.4	7.0	7.8	7.1	5.5	5.8	5.5	6.7
October	10.0	8.8	8.8	9.4	7.7	9.0	8.0	8.6	6.6	4.9	8.7	6.3
November	12.8	13.3	13.0	12.6	*14.1*	13.5	12.5	10.1	8.0	6.4	5.9	6.7
December	14.2	16.0	14.3	16.1	*17.0*	13.9	15.8	13.3	13.1	8.0	9.6	7.2
Annual	9.2	10.2	10.5	*10.9*	10.7	10.1	10.2	9.2	8.1	6.4	6.2	6.4
	P. M.—hour ending at—											
	1	2	3	4	5	6	7	8	9	10	11	12
January	8.1	6.7	6.7	5.6	5.1	6.6	6.6	8.0	7.6	8.0	9.8	11.5
February	6.2	6.0	5.2	5.1	4.8	4.8	6.3	6.3	8.0	7.2	9.7	8.0
March	3.8	4.9	4.2	4.6	4.8	5.3	6.2	6.7	7.3	5.3	5.9	6.9
April	6.1	5.0	6.7	6.8	7.1	5.9	5.9	5.4	6.1	5.8	6.1	4.1
May	9.4	9.5	*10.4*	9.4	9.1	6.7	6.3	5.9	7.5	6.0	6.9	5.5
June	9.6	*12.8*	10.4	8.7	6.2	5.7	7.7	7.3	7.1	7.7	6.2	5.7
July	8.7	8.0	8.3	7.6	6.9	6.1	6.9	6.1	6.9	8.8	7.3	8.3
August	8.0	9.3	8.6	9.3	6.1	5.9	6.6	5.8	9.3	7.2	7.4	9.7
September	7.5	8.7	10.2	*10.9*	8.8	6.7	7.8	9.4	9.6	8.8	7.1	7.1
October	8.0	9.9	9.0	9.9	*10.5*	8.5	7.5	8.6	8.0	7.2	8.7	9.4
November	8.0	9.7	9.6	8.8	8.8	9.1	11.2	11.6	13.7	11.4	11.4	11.8
December	6.6	6.7	6.1	7.7	5.9	8.8	10.7	12.0	12.2	10.5	12.1	11.8
Annual	7.5	8.1	8.0	7.8	7.0	6.7	7.5	7.8	8.6	7.9	8.2	8.3

TABLE 2.—*Six-hour apportionment of rainfall frequency, San Juan, P. R. (1905–1927)*

	A. M.		P. M.			A. M.		P. M.	
	12–6	6–12	12–6	6–12		12–6	6–12	12–6	6–12
January	13.5	10.4	6.5	8.6	August	11.4	8.4	7.9	7.7
February	10.6	8.4	5.4	7.6	September	8.5	6.4	8.8	8.3
March	9.7	6.7	4.6	6.4	October	9.0	6.4	9.3	8.2
April	7.5	5.9	6.3	5.6	November	13.2	8.3	9.0	11.8
May	7.3	6.4	9.1	6.5	December	15.2	11.2	7.0	11.6
June	7.1	6.7	8.9	7.0					
July	10.4	8.4	7.6	7.4	Annual	8.8	7.8	7.5	8.0

TABLE 3.—*Six-hour apportionment of rainfall amounts (per cent), San Juan, P. R. (1905–1927)*

	A. M.		P. M.			A. M.		P. M.	
	12–6	6–12	12–6	6–12		12–6	6–12	12–6	6–12
January	31	26	17	26	August	28	22	33	17
February	31	25	18	26	September	20	16	36	28
March	31	19	25	25	October	20	20	35	25
April	21	16	31	32	November	29	15	26	30
May	17	17	40	26	December	33	24	19	24
June	15	22	43	20					
July	24	26	30	20	Annual	25	20	30	25

METEOROLOGICAL PROBLEMS OF RIGID AIRSHIPS

By F. W. REICHELDERFER

[Bureau of Aeronautics, United States Navy Department, Washington, D. C.]

The growth of aeronautics has not only greatly increased interest in and use of meteorological information, but has laid before the meteorologist new problems, some of which he has never before considered of any great practical importance. The operation of rigid airships in particular brings up many conditions about which exact information is required. The following notes, submitted recently outline specifically some of the conditions which are of interest. Obviously, exact and permanent answers to these questions are impossible. Climatological data are never final. Studies are under way, however, with the view to obtaining information of the conditions outlined. General interest among meteorologists will no doubt bring to light much more information which up to the present time has not been published.

The weather conditions which interest the airship designer and the airship navigator most are gale winds, squalls, especially those not accompanied by clouds and precipitation, and sudden gusts. Given definite in formation of the intensity, extent, etc., of these conditions the designer and navigator can take the steps necessary to surmount their effects. Some of the subjects about which airship interests require more accurate information are:

(*a*) The maximum sudden changes in wind velocity likely to be encountered by airships. This refers to the probable greatest difference between the lull and peak of a wind gust within a few seconds and the frequency of occurrence of these conditions.

(NOTE.—The qualification "probable" or "likely" must be applied to these problems, because there is actually no *practical* limit to the intensity of the weather conditions which may exist. "Likely" and "probable" are taken to include all conditions which airships might be expected to experience at one time or another over a period of 5 or 10 years in regular and frequent operation over the "known" parts of the earth, excepting, of course, the very violent conditions such as tornadoes, thunderstorms, etc., which must be avoided by the usual precautions.)

There is at present considerable information and data available on the above subject and some data on subjects following, but information is not as detailed and accurate as is necessary, especially for design purposes.

(*b*) The maximum acceleration (rate of change) of wind velocity likely to be encountered while the wind direction remains constant. Also the frequency of occurrence of these maximum changes.

(*c*) The maximum change in wind direction likely to be encountered while the velocity remains practically constant. Also the frequency of occurrence.

(*d*) The maximum changes in both the wind direction and the wind velocity which are likely to occur at the same time. Also frequency.

(*e*) The maximum space rate of change in direction and velocity, that is, the maximum change in direction and/or velocity likely to be encountered within a given distance, say, a ship's length of about 800 feet.

(*f*) The minimum distance within which opposing vertical currents of a certain *critical* intensity are likely to be encountered. Also, the frequency. Or, the maximum net difference in velocity which is likely to be encountered within a horizontal distance of, say, 800 feet, of two adjacent, vertical, *sustained* air currents. Especially, in clear air, or in air without the usual towering cumulus clouds which accompany violent convectional currents.

(NOTE.—The intensity of these conditions in well-developed thunderstorms is known to reach values which would be dangerous to the sturdiest aircraft.)

(*g*) The maximum difference in velocity and direction of two horizontal wind currents likely to be encountered within a vertical distance of 100 or 150 feet.

(*h*) The horizontal and vertical extent and the "thickness" in each of the above cases, of wind accelerations exceeding a certain critical value. (These, in order to determine the practicability of circumnavigation.) Also their persistency, in length of time; that is, the total period of their existence.

(*i*) The rapidity with which the foregoing large discontinuities in wind can develop and die out.

In all of the above cases, the conditions needing attention are those which are sustained for an appreciable length of time; that is, for more than a fraction of a second. The conditions should be investigated separately for surface and for upper air. The limits in these different regions will not only be different, but the methods of meeting the conditions on the ground will differ from those in the air. The relative intensity and frequency at various altitudes is important. These conditions need to be studied for different regions, because some regions are more favorable for the formation of violent conditions than are others.

WHENCE COME COLD WAVES?

ALFRED J. HENRY

The literature on the place of origin of cold waves is rather extensive; nevertheless it must be admitted that beyond a general belief that the polar regions are the ultimate source of supply of cold air, little definitive evidence on the subject is at hand.

The explanation of the occurrence of both cold waves and warm waves is to be found in a better knowledge of the N–S component of motion in the atmosphere. It is a matter of common knowledge that the movement of warm air from low to high latitudes is not continuous in the sense that an uninterrupted flow takes place. Because of the fact that cyclones and anticyclones, the two phenomena most directly concerned in the interzonal circulation, are more or less ephemeral, in the sense that they lack continuity of movement across the earth's surface due to changes in environment or what not, uninterrupted flow is not possible. Warm air is transported poleward through the medium of cyclones. The current of warm air, however, may be cut off from the source of supply and then the cyclone, in the nomenclature of the Norwegian school of meteorologists, is said to be "occluded" and soon disappears; generally, but not always, a fresh cyclone is formed a few degrees eastward and southward, where a new current of warm air takes up its journey poleward. This is the principal reason why an uninterrupted passage is impossible; as a matter of fact, there are so many gradations in the volume and speed of movement in both directions, N–S, and the reverse, that it is quite impossible to treat the subject in a detailed way.

In this paper the chief emphasis will be placed on the large variations of pressure and temperature in an attempt to correlate changes in those elements with subsequent weather in the Temperate Zone of the Northern Hemisphere.

A fall in temperature in mid-latitudes and thus the coming of a cold wave is to be expected to the rear of a moving cyclone in winter; the amount of the fall in temperature being conditioned in large degree by the size and intensity of the cyclone. The amplitude of the fall also is more or less dependent upon the intensity and orientation of the anticyclone which immediately follows the cyclone. If the anticyclone be in the form of an elongated ridge of high pressure, places to the eastward of the ridge will experience northerly winds and a greater degree of cold than would obtain if a ridge of equal magnitude were oriented in an east/west direction.

It is suspected that polar air makes its way Equatorward along certain channels which by reason of topographic or other conditions offer the most favorable opportunity of southward flow. Thus I may express the belief that the Mackenzie Basin of North America is the most favorable and probable channel for the flow of polar air Equatorward; the eastern slope of the Canadian Rockies also is a favorable channel. Severe cold may be experienced without the anticyclone plotted on the daily weather map being in visible contact with truly polar air, and thus it has come about that the terms "polar" and "tropical" air are used in a relative sense; indeed, it can be easily shown that what appears to be tropical air to-day was yesterday truly polar air.

Another difficulty in the study of the problem is in the fact as stated by Sir Frederic Stupart, Director Canadian Meteorological Service, as follows:

> In other years the North Pacific cyclonic areas appear to be of such intensity that they force their way into the continent in high latitudes and actually prevent the formation of anticyclones and their concomitant low temperature.[1]

In this paper I have tried, without success, to make contact between the results of the international polar meteorological stations of 1882–83 and the network of meteorological stations in the Temperate Zone of North America. Although the result was a negative one, some interesting conclusions came out of the study and to relate these must be considered as warrant for printing this article.

The stations used and their geographical coordinates are given below:

	North latitude		West longitude	
	°	′	°	′
Point Barrow	71	27	156	15
Fort Rae	62	38	115	43
Fort Conger	81	44	64	45
Jan Mayan	70	59	8	28
			East longitude	
			°	′
Bossekop	69	57	23	15
Nova Zembla	72	22	52	30
Sagastyr	73	23	123	45

The observations at Fort Conger covered the period, August, 1881, to August 8, 1883; those at Point Barrow, November, 1881, to August, 1883, while those for Fort Rae and most of the remaining stations covered a 12 or 13 month period, August, 1882, to August, 1883, both inclusive in most cases.

Inasmuch as the three stations first named were separated from each other by distances ranging from 1,200 to 1,500 miles and by greater distances, except in the case of Fort Rae, from the nearest stations in the mid-latitudes of North America, it was impossible to bridge the large gaps that existed. I was therefore reduced to the alternative of examining the records of the polar stations for internal evidence of large outbreaks, if any, of polar air which might be connected with known meteorological conditions in temperate latitudes. In these latitudes an outbreak of cold northerly air is evidenced by a sharp fall in temperature and a correspondingly sharp rise in pressure and the direction of the wind is almost invariably from north or northwest; in the polar regions, however, cold winds may come from an easterly as well as a northerly quarter.

I have taken out the interdiurnal, or day-to-day, pressure variations for each of the polar stations as being in some measure suggestive of large outbreaks of polar air passing over the station. Inasmuch as the observations were published in extenso, these variations are most easily obtained from the 24-hour daily means of atmospheric pressure. The average daily variation for each month of the year is shown in Table No. 1 below:

TABLE 1.—*Average daily variability of pressure in thousandths of an inch*

Stations	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Point Barrow	0.241	0.154	0.196	0.144	0.087	0.077	0.098	0.116	0.153	0.096	0.177	0.172	0.143
Fort Rae	.195	.160	.196	.181	.124	.125	.086	.122	.168	.121	.196	.209	.156
Fort Conger	.169	.193	.185	.173	.102	.087	.104	.086	.128	.100	.137	.143	.135
Jan Mayan	.220	.295	.189	.201	.118	.083	.063	.098	.157	.142	.173	.142	.147
Bossekop	.213	.220	.257	.131	.092	.080	.073	.102	.088	.116	.116	.161	.137
Nova Zembla	.194	.177	.215	.113	.156	.105	.103	.081	.170	.176	.146	.148	.149
Sagastyr	.133	.130	.137	.116	.114	.173	.098	.094	.146	.138	.163	.175	.135

The interdiurnal variability of pressure has been investigated by several writers, all of whom agree that it is greatest in high latitudes and regularly diminishes thence with approach to the Equator, where it is least.

The chief cause of the greater variation in high than in low latitudes is doubtless the larger contrast in temperature which obtains on the two sides (east and west) of the cyclone in those latitudes. It appears, however, that latitude alone is not the single controlling factor, since the variability is least at Fort Conger, the station having the highest latitude, and it is also small at Sagastyr, the station having the second highest latitude. An additional factor in the causation of large variability of pressure at high latitude stations is the occurrence of cyclones of great intensity that occasionally prevail in high latitudes.

The pressure records of the Point Barrow station show that that station is more frequently visited by intense cyclones than might be supposed. The fact that deep cyclonic systems approach the Alaskan coast of the Bering Sea area from the winter pressure minimum of the Aleutians makes it not only probable but certain that at times an intense cyclone passes eastward along the coast of northern Alaska. One such passed close to or over the station on January 12, 1882, having a central minimum pressure of 28.266 inches and winds of hurricane velocity.

Four days later the most severe windstorm in the life of the Fort Conger station was experienced. The two stations are about 1,200 miles apart, and a travel on the part of the cyclone of but 400 miles per day would accomplish the journey.

The range of the pressure at high latitude stations exceeds an inch in the months when the sun is absent and amounts to about three-quarters of an inch in the

[1] British Association for the Advancement of Science, Toronto meeting of August, 1924.

warm months. While there is abundant evidence of sharp changes in the barometer in high latitudes, evidence of similar changes in temperature is lacking.

The records of Fort Conger show five occasions in February, 1882, when a minimum temperature of more than 60° below zero Fahrenheit was registered, three of the five occurred with rising and the remaining two with falling pressure. The conclusion seems unavoidable that during the long polar night sudden temperature changes rarely or seldom occur. There are cases of slowly falling or rising temperature that persist throughout 8 or 10 days, but the large sudden changes so characteristic of midlatitude stations are rarely, if ever, experienced in the Arctic.

Sverdrup [2] has shown for that part of the Arctic Basin between 155° and 175° east longitude and about 75° north latitude, that the layer of cold surface air is shallow, less than 150 meters in depth; that above this cold layer is an inversion layer of about the same depth; and that above the last named the temperature increases slowly or remains constant to an altitude of 500 to 1,000 meters, where a new decrease begins.

The evidence of large daily rises and falls in the daily mean pressure will now be examined as an indication as to whether or not cyclones are frequent along the rim of the polar basin. The only available station that can be said to be within the basin is Fort Conger, and possibly the Sagastyr station.

I have selected the cases of largest daily rises or falls in the 24-hour mean pressure at each of the stations, taking as the upper limit of rise and fall 0.39 inch, practically 10 millimeters, and as the lower limit 0.20 inch, approximately 5 millimeters. The result of the count is given in Table 2 below.

TABLE 2.—*Data on individual cases of large rises and falls in pressure. Number of rises and falls and ratios at the stations named*

	Rises		Falls		Ratio of large and medium rises to falls of the same magnitude	
	0.39+	0.20–0.38	0.39+	0.20–0.38	Large rises	Medium rises
Point Barrow	6	41	13	38	1:2	1:0.93
Fort Rae	11	50	10	44	1:0.9	1:0.98
Fort Conger	4	34	7	32	1:1.75	1:0.91
Jan Mayan	15	40	11	42	1:0.7	1:1.05
Bossekop	10	30	12	27	1:1.2	1:0.9
Nova Zembla	9	42	16	26	1:1.8	1:0.6
Sagastyr	5	33	8	38	1:1.6	1:1.1

From the above it will be noted that large *falls* in pressure are about twice as numerous as rises of the same magnitude at Point Barrow, Fort Conger, and Nova Zembla, and that large rises and falls are about equal at Fort Rae and Jan Mayan. The next lower group of changes occur with about the same frequency regardless of the sign of the change; if anything the rises slightly outnumber the falls of the same magnitude.

The greater frequency of large falls in pressure as compared with large rises of the same amount is doubtless due to the well-known tendency of the barometer in a cyclone to sink to a lower level, using the normal as a point of reference, than it rises in an anticyclone. It may also be pointed out that the deflective force of the earth's rotation in high latitudes is considerably greater than in mid-latitudes.

CONCLUSIONS

In conclusion it may be said, for North America at least, the evidence of the three international Polar stations is against the idea that aperiodic thrusts of cold air Equatorward take place, and that even under a more favorable distribution of reporting stations than now exists it would be difficult to identify any particular thrust with a subsequent cold wave in temperate latitudes. The cold waves of the latter region, if we may express a belief based on many years experience with the daily weather charts, are doubtless due to an initial southward movement of air which takes place in accordance with the pressure distribution of the moment, most probably about north latitude, say, 60° to 70°, but not necessarily within the polar basin, plus the effect of intense radiation from the snow and ice-covered surface of the continental interior.

The evidence of the Fort Rae station—a station situated, if not within the place of origin of cold waves, yet very close thereto—is adverse to the concept of an outbreak or thrust of cold polar air Equatorward. The speed of the wind at that station on the average of the three winter months is but 1.8 meters per second (4 miles per hour), and high winds are conspicuous by their absence. During the coldest days of the months, November to March, the prevailing wind direction was NNW., although it was calm and equal number of hours. The next most frequent wind direction was SSE., or in the exact opposite direction. The winds from the last named were equally cold with those from a northerly quarter, thus indicating a thorough mixing of the lower layers and a sort of equilibrium temperature after a day or so of northerly winds. Although the Point Barrow station is 18° farther north, the temperatures registered thereat are somewhat higher than at Fort Rae in the cold season.

It is quite probable that cold waves entering the North American Continent by way of the Mackenzie River Valley may have had their place of origin in extreme northeastern Siberia, in the valley of the Anadyr River. A movement thence to western Alaska is but a short journey and almost wholly over a land surface.

I am unable to discover satisfactory evidence of the movement in a northeasterly direction of offshoots from the winter anticyclone of Siberia; when that anti-cyclone is in its normal position, the course of offshoots is then southeast over the Sea of Japan and thence to the Pacific.

For Asia and Europe the problem is simpler; the region in which the international polar stations were located is separated from the northern border of the network of meteorological stations in Europe and Asia by a relatively narrow zone, and it should not be difficult to correlate the two sets of observations. The spread of cold waves in Europe and Asia has been studied by Von Ficker,[3] from whose work it may be inferred that the origin of cold waves in Europe-Asia is within or along the rim of the polar basin.

Von Ficker [4] groups the cold waves of Europe-Asia in three classes as follows:

(*a*) In this group cold air flows from a region of low air temperature in Asiatic Russia, practically in all directions. The relations in this group are comparatively simple although the type is of infrequent occurrence.

(*b*) In this group cold air first appears in the coastal region of the Kara Sea, to the eastward of the Ural Mountains, or in the lower valley of the River Ob, and spreads thence in a complicated way.

(*c*) In this group cold air first appears on the coast of the Kola Peninsula and spreads thence southeast and east toward Europe and Asia.

[2] Sverdrup H. U. The North-Polar cover of cold air, MONTHLY WEATHER REVIEW 53:471–75.

[3] Ficker, H. von, Sitzungsber. Ak. Wiss. Wien, vols. 119 (p. 1769) and 120 (p. 745).

[4] Loc. cit.

UNUSUALLY DRY 'LOW' OF MARCH 28 AND 29, 1928

By L. T. SAMUELS

On March 28 a deep depression covered the Southwestern States with one center (29.40 inches) over Santa Fe and Pueblo and another (29.28 inches) over Wichita. During the ensuing 24 hours this LOW crossed Texas and became centered (29.54 inches) over northeastern Arkansas with a steep pressure gradient producing strong southerly winds over the Gulf States and those adjoining on the north. During this 24-hour period practically *no* precipitation occurred in any of the States traversed by this disturbance.

This fact is unusual in that, ordinarily, southerly winds blowing off the Gulf of Mexico obviously carry an abundance of moisture, which results in more or less precipitation over these regions. It is especially significant, therefore, to find from kite and airplane records obtained at this time that marked temperature inversions accompanied by extremely low relative humidity, prevailed above elevations of 1,000 meters. There follows a tabulation of the kite records from Groesbeck, Tex., and Broken Arrow, Okla., from which it will be observed that extremely dry and warm air characterized the upper levels of the depression during this period. Such lapse rates are decidedly abnormal in low-pressure areas.[1] The records further revealed a thin layer of stratus clouds at the base of the inversion level. The deepening of these clouds was prevented, however, by the existence of the inversion.

MARCH 28, 1928

GROESBECK, TEX.

Time	Elev. (m.) M. S. L.	Temp. °C.	t/100 m.	Rel. hum.	Wind dir.	Vel. (m. p. s.)
7:12 a.	[1] 141	15.6		86	SSW.	8.9
21	679	10.8	0.89	100	S.	24.2
27	921	19.8	−3.10	28	SSW.	22.2

BROKEN ARROW, OKLA.

Time	Elev. (m.) M. S. L.	Temp. °C.	t/100 m.	Rel. hum.	Wind dir.	Vel. (m. p. s.)
11:08 a.	[1] 233	22.7		34	SSW.	9.8
19	753	17.7	0.96	38	SSW.	14.6
21	1,018	20.0	−0.87	13	SW.	16.1
45	2,213	12.3	0.64	3	WSW.	23.0
12:15 p.	2,774	9.3	0.53	9	SW.	22.8
27	3,039	8.0	0.54	4	SW.	27.6

MARCH 29, 1928

GROESBECK, TEX.

Time	Elev. (m.) M. S. L.	Temp. °C.	t/100 m.	Rel. hum.	Wind dir.	Vel. (m. p. s.)
9:05 a.	141	13.0		53	NNW.	8.5
15	710	8.6	0.77	61	NNW.	8.4
27	854	11.8	−2.22	100	WNW.	6.3
38	1,145	13.0	−0.41	100	WNW.	6.4
53	1,276	11.4	1.22	97	W.	10.9
57	1,661	14.4	−0.78	24	W.	11.6
10:28	2,357	10.5	0.56	7	W.	11.3
32	2,534	10.8	−0.17	6	W.	14.7
40	2,833	8.9	0.54	5	WSW.	16.6

BROKEN ARROW, OKLA.

Time	Elev. (m.) M. S. L.	Temp. °C.	t/100 m.	Rel. hum.	Wind dir.	Vel. (m. p. s.)
10:24 a.	233	5.0		65	N.	11.6
34	568	0.8	1.25	85	NNW.	13.3
40	899	−1.9	0.82	100	NNW.	12.8
11:05	1,347	−4.0	0.47	92	N.	
36	1,655	5.8	−3.18	53	NNW.	10.2
46	1,951	3.5	0.78	49	NW.	11.2
53	2,303	3.8	−0.09	20	WNW.	16.2
59	2,828	0.7	0.59	19	WNW.	17.7
12:15 p.	3,594	−5.1	0.66	22	WSW.	33.2

Surface.

[1] "A summary of aerological observations made in well-pronounced highs and lows." By L. T. Samuels, MONTHLY WEATHER REVIEW, May, 1926.

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, MARCH, 1928

By J. BUSTOS NAVARRETE

[Observatorio del Salto, Santiago, Chile]

A slightly increased activity characterized the atmospheric circulation during the month of March; however, the mean path of the depressions ran rather far to the south, between latitudes 40° and 45° S.

Important depressions were charted during the following periods: 2d to 5th, 7th to 10th, 13th to 15th, and 28th to 30th. Precipitation accompanying the second of these storms extended northward to the coast of Arauco, while that caused by the others reached Concepcion. The greatest amount of rainfall for the month was 10.04 inches at Valdivia, where 4.72 inches fell on the 3d.

Between the 11th and the 13th an anticyclone moved from Chiloe toward Argentina; later, from the 19th to the 26th, a second important high-pressure area remained centered in the region of Chiloe and brought a long period of settled weather.

METEOROLOGICAL SUMMARY FOR BRAZIL, MARCH, 1928

By FRANCISCO DE SOUZA, Acting Director

[Directoria de Meteorologia, Rio de Janeiro]

The circulation in the lower strata of the atmosphere was not so active as in the preceding month; however, considerable activity was manifested by the continental depression and the depressions in high latitudes. Six anticyclones, all of small importance, invaded the country from the south; the accompanying fall in temperature, which was considerable in the southern part of the continent, extended to the extreme southern part of Brazil.

In the northern and central regions of the country precipitation was below normal, the deficiencies being 2.60 and 3.11 inches, respectively. In the southern region, on the contrary, there was an abundance of rain, with a mean excess of 1.81 inches.

The weather was generally hot. The abundant rains in the south were generally favorable to crops. In Bahia and the northeast rains were infrequent, especially in the second decade, and this was detrimental to the cane crop and disadvantageous to the planting of cotton, cereals, and vegetables. The gathering of crops of cotton and cereals was completed in the southern, central, and Amazonian regions, and the harvesting of cane was begun in the latter area. The yields were good.

In Rio de Janeiro and vicinity the weather was variable, alternating from fine to unsettled, with general rains on some days. Cloudy days numbered 22 and clear days 9. Temperatures were high; the values for mean daily and mean maximum temperature were 3.6° and 1.4° F. above the respective normals. The extreme readings were 94° on the 1st and 67° on the 31st. In the suburban sections the temperature had still greater range; at Gavea the highest temperature was 102° on the 9th and the lowest was 63° on the 30th. The total precipitation for the month was 6.31 inches, distributed over 17 days. Southerly winds prevailed; at times these were rather cool.—*Transl. by W. W. Reed.*

NOTES

The eighth meeting of the American Geophysical Union at Washington, D. C., April 26–28, 1928.—The sections of meteorology and oceanography of the union held a joint meeting on the above-named dates at which the relations between the sea and the atmosphere and the effect of these relations upon weather and climate was considered. The revised program follows.

The papers presented at the meeting doubtless will be published in full in the series of bulletins issued by the National Research Council.

Revised Program

1. PROBLEMS RELATED TO SOLAR RADIATION

(*a*) Variations of solar radiation, by C. G. Abbot.

(*b*) Amount of solar radiation that reaches the surface of the earth on the land and on the sea, and methods by which it is measured by H. H. Kimball.

(*c*) Amount of solar radiation that reaches lake surfaces, the proportion penetrating the surfaces, the loss of heat by evaporation and back radiation, and the relation or evaporation to meteorological conditions, by N. W. Cummings, Burt Richardson, and I. S. Bowen.

(*d*) The rate at which solar radiation penetrates the surface of lakes and oceans, and the rate at which the surface loses heat as deduced from serial temperature observations, by G. F. McEwen.

(*e*) On the penetration of light in the sea, by E. O. Hulburt.

(*f*) The penetration of solar radiation into lakes, by Edward A. Birge and Chancey Juday.

2. PROBLEMS RELATED TO SURFACE WATER TEMPERATURE

(*a*) Reliability of different methods of taking sea surface temperature, by C. F. Brooks.

(*b*) 1. Significance of temperature measurements not made exactly at the sea surface, by G. F. McEwen.

2. Time required for temperature departures to cross from the western to the eastern side of the ocean, and the changes in their departures during the crossing, by G. F. McEwen.

(*c*) Ocean surface water temperatures—methods of measuring and preliminary results, by Sir Frederic Stupart, J. Patterson, and Dr. H. Grayson Smith.

3. PROBLEMS RELATED TO ATMOSPHERIC CIRCULATION

(*a*) The effect of surface winds upon ocean drift, by G. W. Littlehales.

(*b*) A critical review of the work of the Indian meterological service in monsoon predictions, by R. Hanson Weightman.

(*c*) The effect of ocean currents upon the climate of continents, by A. J. Henry.

Long-range weather forecasting.—Dr. C. E. P. Brooks, in the Meteorological Magazine, May, 1928, treats this subject in a very sane and conservative manner. The editor welcomes the opportunity of presenting readers of this Review with an abstract of the article.

According to Doctor Brooks, the methods of long-range forecasting are very diverse; but leaving the stars out of account, they may be classed under four headings: Periodicities; variations of solar activity; relations between meteorological conditions in different parts of the world, with which we may include ocean temperatures; and extensions of the method of synoptic forecasting.

Taking up these methods seriatim, Doctor Brooks remarks that there has been a great deal of research into periodicity, which has helped our insight into the working of the world's weather, but has proved of little use in forecasting. Weather cycles have not the regularity and permanence of astronomical cycles, and when applied to prediction have an annoying habit of breaking down or changing phase. Several remarkable examples of the breaking down of weather periodicities are given. The activity of Vercelli, in Italy, and Weickmann, in Germany, in developing a so-called periodicity in the variations of atmospheric pressure is considered. This method is still being pursued in Europe.

Forecasting from the variations of solar activity is chiefly associated with the name of Mr. H. H. Clayton, who has found highly complex relations between the occurrence of maxima and minima on the curve of solar radiation obtained at the Smithsonian observatories and the subsequent development of anticyclones and depressions in South America. * * * In this country [England] no relationship has yet been demonstrated between solar phenomena and the weather.

The great majority of successful methods of long-range forecasting at present in use have arisen from the study of the relations between the meteorological conditions in different parts of the world, a branch of investigations chiefly associated with the names of Sir Gilbert Walker, Mr. E. W. Bliss and Professor Exner.

The work in India and Egypt falls into this category, and makes use of antecedent conditions as far away as South America; investigations on similar lines are being carried out in Rhodesia and altogether it seems probable that in most tropical countries the problem of long-range forecasting depends for its solution on the coordination of the succession of the seasons in all parts of the world.

Speaking of the attempt to relate ice conditions in Barents Sea with subsequent weather—the work of W. Wiese and Lieut. Commander E. H. Smith [1]—the author remarks that very little progress has been made as yet in applying this method to long-range forecasts for the British Isles, because, in the main, the method is essentially "seasonal"; i. e., it is only applicable to countries where the meteorological conditions usually remain sensibly constant for several months, and again the weather of the British Isles is not bound up with the fluctuations of intensity of any one "centre of action," but is influenced in turn by at least three such centers—Iceland, the Azores, and Siberia.

Previous studies carried out at the British meteorological office have shown that abnormal seasons in the British Isles depend much less on variations in the intensity of the Icelandic minimum or the Azores HIGH than on displacements of their position. Hence the problem of the British Isles is to forecast such displacements. A detailed account is then given of the work of the British meteorological office toward gaining greater knowledge of these displacements.[2] Some of the difficulties are next pointed out. In the first place, before such forecasts can attain a high degree of success a good deal of further research will be necessary; the month is too large a unit, but the month is the unit normally adopted in the publication of climatological results, and the labor of repeating the work with a smaller unit would be very great.

Again these centers, and especially those in which pressure is below normal, often depart from the usual tracks or die out, and thus would falsify the forecasts. To discover the reason for these irregularities is likely to require a great deal of laborious research, only a small part of which has yet been carried out. Hence, although this method seems at present to offer the best prospect of real long-range forecasts being ultimately practicable in this country, the time is not just yet.

[1] This Review 55: 409–410.

[2] Variations of pressure from month to month in the region of the British Isles. London Q. J. R. Metl. Soc., 52:263.

Ocean temperatures come in for considerable space. Concerning these the author remarks: "Actually a small influence has been traced,[3] but it represents only a very small fraction of the variability of our weather. The fallacy in the reasoning is that the Gulf Stream is not only an important factor of our climate but is also an extremely stable factor, and the differences from year to year in the amount of heat which it carries into the North Atlantic are very small compared with the average amount of heat which it brings in any one year."

The method of extension of the synoptic chart also receives some attention; it is pointed out that the study of the general tendencies of the pressure distribution revealed by the monthly pressure charts may at times assist the forecaster from daily synoptic charts, especially when he is considering the "further outlook" and so lead to the more frequent issue of what may be termed "medium-range" forecasts, perhaps the most useful form of all for the general public.—*A. J. H.*

Abandonment of telegraph circuit system in the Weather Bureau.—The plan of collecting weather reports inaugurated in 1871 was formally abandoned and a new system adopted on April 1, 1928.

In the new system each Weather Bureau station files its report in the local telegraph office for transmission over the ordinary commercial lines to either one or the other of the two general receiving and distributing points—Chicago and New York. These offices of the telegraph company maintain a special organization for the purpose of quickly duplicating the original reports as they come in from the individual stations. Thus if a report is to be sent to 140 stations in addition to the two distributing centers, that number of duplicates are made by a stencil process and the duplicates are delivered to the wires over which they must pass to their destination.

[3] The effect of fluctuations of the Gulf Stream in the distribution of pressure over the eastern North Atlantic and western Europe. London Meteorological Office Geophys. Mem. 4, No. 34.

Under the old system a telegraph operator could send or receive a single message one way at a time and he utilized the entire capacity of the wire. The use of automatic apparatus that has been developed in recent years permits the automatic utilization of 3 or 4 channels each way on a single wire, thus greatly increasing the amount of traffic that can be carried on a single wire. The new system enables the bureau to collect and distribute its reports in a little less time than was consumed by the old system.

Symposium on light therapy.—The English journal, Nature, for April 21, 1928, contains a supplement of 18 pages devoted to various aspects of "light therapy."

Prof. F. Ll. Hopwood deals with the physical basis of light used for therapeutic purposes; Prof. Leonard Hill, with the biological action of ultra-violet rays; Dr. W. Kerr Russell, with the physicological action of ultra-violet radiation and its use in the home; Prof. S. Russ, with ultra-violet radiation for domestic use.

Mr. P. R. Peacock treats of medical aspects of "artificial sunlight" in private houses; Mr. C. T. Angus, of lamps for light baths; Mr. B. D. H. Watters of selection of ultra-violet lamps for home use, and, finally, Dr. L. C. Martin discusses the ultra-violet transmission of transparent materials.

April weather in the United States 50 years ago.—April, 1878, was the fourth consecutive warm month in the United States, and like the preceding month it was characterized by exceptionally low pressure in the Missouri and Upper Mississippi Valleys and the Lake region, averaging as much as two-tenths of an inch below the normal. Pressure was also low in Pacific Coast States and at St. Michaels, Alaska. It was high in Greenland and the Arctic regions of northern Europe. Two severe storms crossed the country attended by heavy snow in northern Rocky Mountain States and high winds in the Lake region. The rainfall of the month was generally ample for all needs.—*A. J. H.*

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

American geographical society.

. . . Problems of polar research; a series of papers by thirty-one authors. New York. 1928. v, 479 p. illus. maps. diagrs. 26 cm. (Amer. geogr. soc. Spec. pub. no. 7.) [Contains meteorological articles.]

Bellescize, de.

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Climatic control. Ed. 3. London. 1927. viii, 168 p. front. illus. plates. diagrs. 17½ cm.

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De Geer, Gerard.

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Pilotnye issledovaniia atmosfery. (Results of the pilot-balloon observations.) Vyp. 1, 1925. Kostroma. 1928. 31 p. 31 cm.

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Georgii, Walter.

Flugmeteorologie. Leipzig. 1927. viii, 237 p. figs. plates. 23½ cm.

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING APRIL, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the Review for January, 1924, **52:** 42, January, 1925, **53:** 29, and July, 1925, **53:** 318.

Table 1 shows that solar radiation intensities averaged slightly above the normal values for April at Lincoln, Nebr., and close to normal at Washington, D. C., and Madison, Wis. At Washington an intensity of 1.50 gram-calories per minute per square centimeter, measured at noon on the 25th, is nearly equal to the absolute maximum for April of 1.51.

Table 2 shows a slight excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at Madison and Lincoln, and a slight deficiency at Washington as compared with the April normals for these stations.

Skylight polarization measurements at Washington made on two days give a mean of 57 per cent, with a maximum of 59 per cent on the 25th. These are close to the corresponding normal values for Washington for April. At Madison polarization measurements obtained on three days give a mean of 67 per cent, with a maximum of 72 per cent on the 27th. These are above the corresponding normal values for Madison for April.

TABLE 1.—*Solar radiation intensities during April, 1928*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	A. M. Air mass				P. M. Air mass					Local mean solar time
	e.	5.0	4.0	3.0	2.0	¹1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Apr. 2	4.95				0.92						3.99
5	9.83				0.99						9.14
12	5.36				1.09						5.79
13	4.75		0.90	1.01	1.17	1.49					3.30
18	4.37	0.66	0.80	0.97	1.18	1.45	1.04	0.78	0.59		3.00
25	4.17				1.08	1.53	1.20	1.00	0.85	0.64	3.00
26	3.81	0.60	0.74	0.92	1.12						3.99
Means		(0.63)	0.81	0.97	1.08	1.49	(1.12)	(0.89)	(0.72)	(0.64)	
Departures		−0.06	+0.05	+0.07	±0.00		+0.02	−0.02	−0.03	−0.02	

MADISON, WIS.

Date	8 a. m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Apr. 3	6.27				0.97						7.57
9	3.00			1.15							1.52
12	3.90				1.28	1.56					3.30
17	3.45			0.98	1.14	1.48					3.63
23	4.17				1.30						3.45
27	3.63				1.31	1.48					3.45
28	3.45				1.31						2.49
Means				(1.06)	1.22	1.15					
Departures				−0.03	±0.00						

LINCOLN, NEBR.

Date	8 a. m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Apr. 9	1.60		0.99	1.11	1.30	1.52	1.20	1.06	0.93	0.82	3.81
19	2.36						1.18	0.93			1.96
22	4.57					1.51	1.25	1.07	0.91	0.81	2.74
23	5.36				1.23	1.46					4.17
24	3.45			1.07	1.21	1.37	1.23	1.05	0.93	0.79	2.49
25	3.30				1.18	1.40					3.15
27	4.17	0.86	0.97	1.06	1.25	1.48	1.21	0.99	0.82	0.66	2.49
28	3.45		0.84	1.01	1.14	1.28					4.57
Means		(0.86)	0.93	1.06	1.22	1.43	1.21	1.02	0.90	0.77	
Departures		+0.12	+0.09	+0.07	+0.01		+0.03	+0.03	+0.05	+0.05	

¹ Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1928	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Apr. 1	436	237	378	175	407	324	+51	−137	−36
Apr. 8	347	480	475	294	309	377	−59	+75	+51
Apr. 15	415	435	423	390	432	312	−12	+29	−23
Apr. 22	288	528	620	376	237	367	−130	+94	+140
Excess or deficiency since first of year on Apr. 28							−616	+1,092	+259

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent, U. S. Naval Observatory]
[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson observatories]
[The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
1928	h. m.	°	°	°			
Apr. 1 (Naval Observatory).	14 16	−72.0	228.5	−8.5	123		
		−58.5	242.0	+20.5	62		
		−28.0	272.5	+10.0	77		
		−23.0	277.5	+8.0	77		
		−12.0	288.5	+22.0		170	
		−5.0	295.5	+9.5		22	
		−4.5	296.0	+6.0	31		
		+48.5	349.0	−11.0	123		685
Apr. 2 (Naval Observatory).	11 42	−83.0	205.7	−17.0		463	
		−60.5	228.2	−9.0	123		
		−45.0	243.7	+20.5	15		
		−17.5	271.2	+10.5	62		
		−11.0	277.7	+8.0		154	
		−2.5	286.2	+6.5		6	
		−1.5	287.2	+22.0	154		
		+7.5	296.2	+10.0		9	
		+8.0	296.7	+6.5	31		
		+60.5	349.2	−11.0	123		1,140
Apr. 3 (Naval Observatory).	11 48	−70.5	204.9	−17.0		494	
		−67.5	207.9	−24.5		62	
		−47.0	228.4	−9.0	93		
		−4.0	271.4	+10.5	37		
		−1.0	274.4	+7.5	139		
		+5.0	280.4	+8.0		62	
		+11.5	286.9	+22.0	139		
		+12.0	287.4	+7.0		46	
		+21.5	296.9	+7.5		25	
		+73.5	348.9	−11.0	123		1,220
Apr. 4 (Naval Observatory).	11 32	−70.0	192.4	−10.0	15		
		−68.0	194.4	−15.0	31		
		−67.0	195.4	+17.0		185	
		−60.0	202.4	−13.5		216	
		−55.0	207.4	−17.0	370		
		−52.0	210.4	−22.5	31		
		−33.0	229.4	−8.5	62		
		+10.0	272.4	+10.5	31		
		+12.5	274.9	+7.5		154	
		+18.0	280.4	+8.0	139		
		+24.5	286.9	+22.0	139		
		+27.0	289.4	+6.0		25	
		+34.5	296.9	+6.0	15		1,413
Apr. 5 (Naval Observatory).	11 39	−56.0	193.1	−10.5	15		
		−52.5	196.6	+17.0		123	
		−49.0	200.1	−14.0		185	
		−42.5	206.6	−17.0	401		
		−40.0	209.1	−23.5		62	
		−19.5	229.6	−8.5	77		
		+4.0	253.1	+14.5	22		
		+22.5	271.6	+11.0	15		
		+29.5	278.6	+8.0		216	
		+38.0	287.1	+21.5	123		
		+48.0	297.1	+6.0	9		1,248
Apr. 6 (Naval Observatory).	11 37	−82.0	153.9	−15.5	154		
		−40.0	195.9	+17.0		154	
		−37.0	198.9	−14.0		247	
		−29.5	206.4	−17.0	463		
		−27.0	208.9	−24.0		62	
		−6.5	229.4	−8.0	77		
		+17.5	253.4	+14.5		31	
		+35.0	270.9	+11.0	15		
		+42.5	278.4	+8.0		154	
		+50.0	285.9	+21.5		123	1,480

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
1928	h. m.	°	°	°			
Apr. 7 (Naval Observatory).	11 35	−70.0	152.8	−15.5	139		
		−36.5	186.3	−9.5		22	
		−32.5	190.3	+18.0		15	
		−26.0	196.8	+16.0	139		
		−22.0	200.8	−14.0		432	
		−16.5	206.3	−17.0	370		
		−13.5	209.3	−25.0		93	
		−3.0	219.8	−7.5		46	
		+7.0	229.8	−8.5	77		
		+29.0	251.8	+13.5		18	
		+49.0	271.8	+11.0	31		
		+52.0	274.8	+7.5	123		
		+59.5	282.3	+8.0		62	
		+61.5	284.3	+21.0	93		1,660
Apr. 8 (Naval Observatory).	11 36	−81.0	128.6	+13.0		463	
		−70.5	139.1	−16.0		62	
		−56.0	153.6	−15.5	123		
		−18.0	191.6	+17.5		31	
		−12.5	197.1	+15.5		139	
		−9.0	200.6	−14.0		432	
		−2.5	207.1	−17.0	370		
		−1.0	208.6	−25.0		139	
		+11.5	221.1	−8.0		77	
		+20.5	230.1	−9.0	77		
		+41.5	251.1	+13.0	9		
		+61.0	270.6	+11.0	31		
		+64.5	274.1	+7.5		139	
		+74.0	283.6	+21.0	123		2,215
Apr. 9 (Naval Observatory).	12 56	−66.0	129.6	+13.5		370	
		−59.5	136.1	−17.5		185	
		−41.5	154.1	−15.5		170	
		0.0	195.6	−16.0		93	
		+1.5	197.1	+15.0		93	
		+7.5	203.1	−16.0		401	
		+12.0	207.6	−17.5	247		
		+28.0	223.6	−7.5	46		
		+34.5	230.1	−8.5	77		1,682
Apr. 10 (Harvard)	16 17	−72.0	108.5	−12.0		204	
		−69.5	111.0	+7.0	388		
		−51.5	129.0	+12.0		1,022	
		−42.0	138.5	−19.5		104	
		−25.5	155.0	−16.0	119		
		+17.5	198.0	+15.5		67	
		+25.5	206.0	−14.0		818	
		+51.0	231.5	−7.0	47		2,769
Apr. 11 (Mount Wilson)	19 0	−56.0	109.9	−9.5		725	
		−56.0	109.9	+9.5	251		
		−37.0	128.9	+14.0		456	
		−30.0	135.9	−18.0		65	
		−12.0	153.9	−15.0		138	
		+2.0	167.9	−16.0		25	
		+31.0	196.9	+15.0		145	
		+38.0	203.9	−15.5		799	
		+62.0	227.9	−9.5	30		2,634
Apr. 12 (Naval Observatory).	11 40	−52.5	104.1	−10.5		154	
		−45.0	111.6	+8.5	247		
		−42.5	114.1	−8.0		278	
		−27.0	129.6	+13.0		216	
		−21.5	135.1	−19.5	31		
		−15.5	141.1	−16.0	25		
		−2.5	154.1	−15.5		93	
		+42.0	198.6	+14.5		62	
		+44.0	200.6	−15.0		216	
		+51.0	207.6	−17.0		370	1,692
Apr. 13 (Naval Observatory).	11 45	−40.0	103.5	−10.5	123		
		−31.0	112.5	+9.0		170	
		−29.0	114.5	−8.5		278	
		−12.5	131.0	+13.0		130	
		−8.0	135.5	−19.5	18		
		−2.5	141.0	−16.5	9		
		+10.5	154.0	−16.0		46	
		+55.0	198.5	+14.0	31		
		+57.0	200.5	−15.0		185	
		+63.0	206.5	−16.5		218	1,215
Apr 14 (Mount Wilson).	18 30	−15.0	111.5	−10.0		304	
		−14.0	112.5	+8.5		222	
		+4.0	130.5	+13.0		85	
		+11.0	137.5	−18.0		22	
		+26.5	153.0	−16.0		36	
		+50.5	177.0	+18.0		60	
		+76.0	202.5	−14.0		219	948
Apr. 15 (Naval Observatory).	13 35	−12.0	104.1	−10.5		93	
		−5.0	111.1	−10.0		93	
		−3.5	112.6	+9.0		185	
		+1.0	117.1	−8.5	154		
		+14.5	130.6	+12.5		93	
		+38.5	154.6	−16.5		77	
		+58.0	174.1	+19.0	62		757
Apr. 16 (Naval Observatory).	12 12	+0.5	104.1	+7.0		31	
		+1.5	105.1	−9.5		46	
		+8.0	111.6	−10.0		15	
		+9.0	112.6	+10.0		185	
		+14.5	118.1	−7.5	170		
		+27.5	131.1	+15.0		108	
		+80.0	183.6	+19.0		123	678

Positions and areas of sun spots—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longi-tude	Lati-tude	Spot	Group	
1928	h.	m.	°	°	°			
Apr. 17 (Naval Observatory).	11	58	−41.0	49.5	−10.0	6		
			+13.5	104.0	−9.0		9	
			+14.5	105.0	+7.5		9	
			+17.5	108.0	−9.5		6	
			+22.0	112.5	−10.0	25		
			+22.0	112.5	+10.0	154		
			+28.0	118.5	−7.5	123		
			+40.0	130.5	+17.5		46	378
Apr. 18 (Naval Observatory).	12	12	+35.0	112.2	−10.0	19		
			+35.5	112.7	+9.5	139		
			+41.0	118.2	−7.5	123		
			+53.5	130.7	+17.5		15	296
Apr. 19 (Naval Observatory).	13	7	−78.0	345.5	−11.0	204		
			−72.0	351.5	−9.5	31		
			+0.5	64.0	−8.0		15	
			+49.5	113.0	−10.5	9		
			+50.0	113.5	+9.0	170		
			+54.5	118.0	−7.5	93		522
Apr. 20 (Naval Observatory).	12	27	−65.0	345.6	−11.0	154		
			−59.5	351.1	−9.5		31	
			+12.5	63.1	−8.0		46	
			+60.5	111.1	−10.0	6		
			+61.5	112.1	+9.0	185		
			+67.5	118.1	−7.5	108		530
Apr. 21 (Harvard)	11	21	−51.0	347.0	−12.5	315		
			+79.5	117.5	+10.0	314		
			+87.0	125.0	−6.5	382		1,011
Apr. 22 (Mount Wilson)	12	45	−53.0	331.0	+9.5		49	
			−39.0	345.0	−12.0	307		356
Apr. 23 (Yerkes)	12	16	−25.0	347.0	−16.0	300		300
Apr. 24 (Naval Observatory).	11	36	−80.0	278.3	−18.0	93		
			−75.0	283.3	−13.5		185	
			−24.5	333.8	+8.5		25	
			−12.5	345.8	−12.0		185	488
Apr. 25 (Naval Observatory).	11	46	−79.0	266.0	−18.5		185	
			−72.0	273.0	−14.0	77		
			−69.0	276.0	−16.5		93	
			−61.5	283.5	−13.5	278		
			−17.5	327.5	+10.5		31	
			−12.0	333.0	+8.0		62	
			+0.5	345.5	−12.0	216		942
Apr. 26 (Naval Observatory).	11	42	−67.5	264.3	−18.5		185	
			−59.5	272.3	−14.0	77		
			−57.0	274.8	−17.0	31		
			−48.0	283.8	−13.5	247		
			−10.0	321.8	+18.0	9		
			+1.5	333.3	+8.0	31		
			+13.0	344.8	−12.0	154		734
Apr. 27 (Harvard)	10	20	−77.0	242.5	+9.5	786		
			−51.0	268.5	−18.0		317	
			−35.0	284.5	−14.5	393		
			+28.0	347.5	−11.5	271		1,767

Positions and areas of sun spots—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longi-tude	Lati-tude	Spot	Group	
1928	h.	m.	°	°	°			
Apr. 28 (Mount Wilson)	14	15	−67.0	236.9	+22.0		74	
			−59.0	244.9	+10.0		242	
			−38.0	265.9	−17.0		293	
			−20.0	283.9	−14.0	327		
			+30.0	333.9	+8.0		8	
			+42.0	345.9	−11.0	230		1,174
Apr. 29 (Naval Observatory).	11	40	−58.0	234.2	+9.5		31	
			−54.5	237.7	+22.5		154	
			−48.0	244.2	+9.5		247	
			−35.0	257.2	+14.5	31		
			−27.5	264.7	−18.0		139	
			−20.0	272.2	−14.5	31		
			−8.5	283.7	−13.5	247		
			+54.5	346.7	−12.0	185		1,065
Apr. 30 (Naval Observatory).	12	2	−77.5	201.2	−11.0		216	
			−70.0	208.7	−11.0		108	
			−41.0	237.7	+22.0		62	
			−37.5	241.2	+9.0		46	
			−32.5	246.2	+10.5		216	
			−15.0	263.7	−13.5		22	
			−14.5	264.2	−19.0		46	
			−7.0	271.7	−14.0	25		
			+4.5	283.2	−13.5	185		
			+16.0	294.7	−19.0		31	
			+68.5	347.2	−12.0	154		1,111
Mean daily area for April								1,137

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR APRIL, 1928

[Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland]

March	Relative numbers	March	Relative numbers	March	Relative numbers
1		11	125	21	22
2		12	110	22	21
3	76	13	93	23	24
4	95	14	82	24	28
5	111	15	91	25	44
6	126	16	82	26	52
7	121	17		27	50
8	136	18	26	28	55
9	134	19	39	29	67
10	109	20	40	30	92

Number of observations, 27; mean, 76.0.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperatures were decidedly below normal for the month with the exception of those at Washington, where small positive departures occurred at most levels. In agreement with Climatological Chart 1, the largest negative departures occurred in the extreme northern and southern sections of the country. It will be seen from Table 1 that unusually large temperature departures persisted to the highest levels at Groesbeck, Ellendale, and Royal Center.

Notwithstanding the subnormal free-air temperatures, the average relative humidities were likewise below normal at practically all stations. This fact is apparently of significance in connection with the small amount of precipitation which occurred at most of the stations during the month, Royal Center having the smallest amount on record for April.

Vapor pressures averaged below normal at all stations and altitudes with the exception of the lower levels at Washington.

Free-air resultant wind velocities were considerably in excess of the average at Washington and Ellendale and near the average at the other stations. Resultant directions for the month showed a decided lack of southerly component at most stations and levels. This was in harmony with the negative temperature departures

Record minimum temperatures for April accompanied high-pressure areas on the 7th–9th, 14th, and 27th–28th. Temperature departures ranged from 20° C. below the average at 1,500 meters at Ellendale on the 8th to 14° C. below at 2,000 meters at Due West on the 28th.

Conditions of special interest occurred on the 27th and 28th when northeasterly winds prevailed at exceptionally high altitudes over the Lake region. At the time this section of the country was situated between a high-pressure area to the west and a low to the east. The 6 a. m. pilot-balloon observation of the 27th at Royal Center revealed a north-northeast wind from 500 to 5,000 meters. Both the velocity (10 m. p. s.) and direction of this wind were remarkably steady throughout this great depth. A kite flight made at the same time showed an unusually uniform lapse rate (0.59° C. per 100 meters) from the top of the St. Cu. layer (650 meters) to the maximum altitude reached (5,000 meters) with the relative humidity throughout this layer under 40 per cent.

At 5,000 meters an abrupt shift in the wind direction from north-northeast to southwest occurred. It was accompanied by a tremendous increase in velocity which reached more than 40 m. p. s. at 8,000 meters. At 1:45 p. m. of the 27th at Sault Ste. Marie this north-northeast wind extended to 7,000 meters, at which altitude the balloon was lost sight of.

The northeasterly winds at these high elevations appear to be associated with the extreme southerly course taken by this high-pressure area instead of the more usual easterly one. On the morning of the 29th its *center* was apparently over the Gulf of Mexico.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during April, 1928*

TEMPERATURE (°C.)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center Ind. (225 meters)		Washington, D. C. (7 meters)[1]	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Meters												
Surface	13.7	−1.7	14.1	−2.6	2.7	−3.0	14.8	−3.1	8.6	−1.6	13.6	+1.6
250	13.6	−1.7	13.8	−2.6			14.0	−3.2	8.4	−1.5	11.5	+1.3
500	11.9	−1.8	11.9	−2.3	2.2	−3.2	12.0	−3.6	5.9	−1.8	9.3	+0.8
750	10.3	−2.0	10.6	−2.1	0.3	−3.7	10.6	−4.0	4.1	−2.3	7.5	+0.5
1,000	9.1	−2.2	9.5	−2.0	−0.7	−3.6	10.4	−3.6	2.9	−2.5	5.8	+0.1
1,250	8.0	−2.3	8.2	−2.0	−1.6	−3.4	11.0	−2.4	2.0	−2.3	4.2	−0.3
1,500	7.0	−2.2	6.8	−2.0	−2.6	−3.3	11.0	−1.8	1.2	−2.1	3.0	−0.2
2,000	5.7	−1.2	4.4	−1.5	−5.0	−3.2	8.7	−2.0	−1.2	−2.2	1.3	+0.1
2,500	3.3	−0.7	2.8	−0.7	−7.9	−3.3	6.8	−1.3	−3.6	−2.0	0.6	+1.2
3,000	−0.1	−1.0	0.4	−0.5	−11.2	−3.6	3.4	−1.8	−6.0	−1.8	−3.4	−0.4
3,500	−3.5	−1.3	−2.5	−0.8	−14.5	−3.9	0.0	−2.3	−8.6	−1.8		
4,000	−6.9	−1.7	−5.5	−1.2	−17.0	−3.3	−4.2	−3.3	−11.8	−2.6		
4,500	−9.5	−1.4			−19.7	−3.1	−8.1	−4.4	−15.1	−3.1		
5,000									−18.2	−3.3		

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during April, 1928*—Continued

RELATIVE HUMIDITY (%)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center Ind. (225 meters)		Washington, D. C. (7 meters)[1]	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Meters												
Surface	60	−4	68	+7	61	−4	73	+1	63	−1	57	−3
250	60	−4	68	+7			73	+1	63	−1	58	−2
500	57	−6	67	+5	61	−3	74	+3	65	+1	58	−1
750	57	−5	64	+2	61	−1	73	+4	65	+2	58	0
1,000	56	−4	61	−1	59	−1	63	0	64	+3	59	+1
1,250	54	−3	61	−1	56	−3	52	−5	61	+2	58	0
1,500	52	−3	60	−1	51	−6	43	−7	56	−2	56	−3
2,000	40	−10	52	−6	50	−5	41	−3	51	−5	53	−5
2,500	39	−10	44	−8	50	−4	31	−11	43	−9	48	−8
3,000	43	−6	42	−7	52	−2	30	−11	38	−11	42	−12
3,500	47	−3	39	−5	54	−1	30	−13	39	−10		
4,000	45	−3	42	−2	28	−27			41	−7		
4,500	29	−20			4	−48			37	−8		
5,000									39	−4		

VAPOR PRESSURE (MB.)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center Ind. (225 meters)		Washington, D. C. (7 meters)[1]	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	9.83	−1.83			4.45	−1.39	13.08	−2.20	7.29	−1.14	9.31	+0.38
250	9.72	−1.83	11.11	−0.78			12.54	−2.05	7.14	−1.14	8.31	+0.27
500	8.33	−1.87	10.92	−0.77	4.32	−1.36	11.38	−1.58	6.22	−0.96	7.35	+0.24
750	7.42	−1.68	9.69	−0.71	3.74	−1.28	10.12	−1.49	5.54	−0.90	6.54	+0.16
1,000	6.76	−1.43	8.65	−0.82	3.36	−1.19	8.51	−1.61	5.00	−0.72	5.87	+0.06
1,250	6.08	−1.20	7.75	−0.99	2.95	−1.18	7.03	−1.64	4.57	−0.70	5.17	−0.22
1,500	5.45	−1.06	7.10	−0.85	2.52	−1.19	5.36	−1.78	3.91	−0.88	4.55	−0.47
2,000	3.37	−1.62	6.15	−0.90	2.04	−0.93	3.89	−1.49	3.11	−0.85	3.71	−0.51
2,500	2.57	−1.38	4.27	−1.10	1.64	−0.76	2.31	−2.01	2.13	−0.87	3.33	−0.15
3,000	2.07	−1.14	3.05	−0.90	1.43	−0.50	1.69	−1.84	1.68	−0.67	2.18	−0.46
3,500	1.61	1.04	2.31	−0.62	1.19	−0.39	1.17	−1.82	1.39	−0.60		
4,000	0.95	1.13	1.77	−0.46	0.69	−0.57			1.11	−0.59		
4,500			1.46	−0.30	0.37	−0.54			0.73	−0.66		
5,000									0.64	−0.55		

[1] U. S. Naval Air Station, Washington, D. C.

TABLE 2.—*Free-air resultant winds (m. p. s.) during April, 1928*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)			
	Mean		Normal		Mean		Normal		Mean		Normal	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°	
Surface	S. 35 W.	2.6	S. 9 W.	2.5	S. 13 W.	1.1	S. 69 W.	1.4	N. 35 W.	2.9	N. 18 W.	1.6
250	S. 36 W.	2.6	S. 11 W.	2.6	S. 2 W.	0.9	S. 73 W.	1.4				
500	S. 36 W.	3.1	S. 13 W.	3.9	S. 45 W.	2.1	S. 69 W.	2.6	N. 36 W.	2.9	N. 17 W.	1.7
750	S. 31 W.	3.2	S. 17 W.	4.7	S. 51 W.	3.2	S. 67 W.	3.3	N. 46 W.	3.8	N. 32 W.	1.3
1,000	S. 41 W.	4.0	S. 30 W.	5.2	S. 62 W.	4.4	S. 66 W.	4.3	N. 49 W.	4.3	N. 55 W.	1.6
1,250	S. 53 W.	3.6	S. 41 W.	5.3	S. 68 W.	6.2	S. 69 W.	6.0	N. 49 W.	4.5	N. 61 W.	2.3
1,500	S. 68 W.	4.1	S. 54 W.	5.9	S. 77 W.	7.5	S. 71 W.	7.3	N. 49 W.	5.3	N. 64 W.	2.8
2,000	S. 79 W.	5.1	S. 65 W.	7.0	S. 67 W.	9.2	S. 77 W.	8.5	N. 47 W.	5.3	N. 74 W.	3.3
2,500	S. 88 W.	6.3	S. 72 W.	7.7	S. 74 W.	11.0	S. 78 W.	10.1	N. 53 W.	6.8	N. 80 W.	5.0
3,000	S. 80 W.	8.1	S. 79 W.	7.8	S. 75 W.	10.3	S. 79 W.	10.8	N. 51 W.	9.3	N. 76 W.	6.8
3,500	N. 88 W.	9.9	S. 87 W.	9.8	N. 89 W.	11.2	N. 89 W.	11.6	N. 55 W.	13.0	N. 75 W.	8.2
4,000	N. 87 W.	11.8	S. 81 W.	11.0	N. 84 W.	10.8	N. 83 W.	12.3	N. 42 W.	16.4	N. 70 W.	9.7
4,500	N. 45 W.	11.0	W.	11.7					N. 28 W.	13.6	N. 58 W.	9.2
5,000	N. 22 W.	9.9	N. 81 W.	10.3								

Altitude m. s. l.	Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		Normal		Mean		Normal		Mean		Normal	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°	
Surface	S. 9 W.	2.5	S.	2.4	S. 56 W.	2.2	S. 47 W.	1.5	S. 74 W.	0.8	N. 40 W.	1.3
250	S. 6 W.	2.8	S. 2 E.	3.1	S. 56 W.	2.3	S. 45 W.	1.7	S. 77 W.	4.6	N. 69 W.	2.7
500	S. 3 W.	3.9	S. 2 W.	4.6	S. 48 W.	4.8	S. 45 W.	3.4	S. 84 W.	7.3	N. 74 W.	4.2
750	S. 4 W.	4.2	S. 10 W.	5.1	S. 53 W.	6.4	S. 52 W.	4.4	S. 88 W.	8.9	N. 68 W.	5.3
1,000	S. 16 W.	4.7	S. 20 W.	5.7	S. 61 W.	7.1	S. 59 W.	4.8	S. 88 W.	8.6	N. 64 W.	5.8
1,250	S. 29 W.	4.9	S. 31 W.	6.0	S. 73 W.	7.4	S. 71 W.	5.9				
1,500	S. 40 W.	4.5	S. 37 W.	6.6	S. 80 W.	8.0	S. 80 W.	6.7	N. 85 W.	11.3	N. 63 W.	7.9
2,000	S. 64 W.	6.6	S. 50 W.	7.5	N. 82 W.	9.8	S. 88 W.	8.1	N. 75 W.	12.2	N. 71 W.	8.9
2,500	S. 68 W.	6.6	S. 59 W.	8.1	N. 73 W.	12.6	N. 85 W.	9.0	N. 68 W.	14.0	N. 66 W.	10.9
3,000	S. 89 W.	9.2	S. 65 W.	9.9	N. 77 W.	13.0	N. 83 W.	10.8	N. 72 W.	13.3	N. 83 W.	18.1
3,500	N. 73 W.	11.3	S. 71 W.	9.9	N. 76 W.	13.0	W.	12.1	N. 80 W.	13.3	N. 71 W.	10.6
4,000					N. 80 W.	9.5	N. 86 W.	12.9	N. 66 W.	14.0	N. 74 W.	12.5
4,500					N. 80 W.	10.7	N. 75 W.	13.5	N. 70 W.	14.5	N. 73 W.	12.2
5,000					N. 81 W.	10.6	N. 76 W.	12.0	N. 68 W.	17.4	N. 70 W.	13.0

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

The important feature of the weather during April, 1928, was the persistent cold that existed almost continuously after the first week over nearly all districts. This was in marked contrast with conditions during the three preceding months, which were mainly unusually warm.

PRESSURE AND WINDS

Changes in barometric pressure were mainly only moderate, but their general trend was productive of cool weather which, continuing almost without break until near the end, delayed the normal temperature advance, and at the close the season was generally a week to 10 days or even more late.

The cyclones, while productive of much precipitation in the lower Mississippi Valley and to eastward over the Gulf and Atlantic Coast States, were generally without importance in the early stages of their development.

The first important cyclone attended by heavy and widespread precipitation developed over the Southwest, reaching the southern plains on the morning of the 5th, by which time considerable precepitation had occurred as far east as the Mississippi Valley and upper Lake region. This storm advanced slowly toward the Great Lakes from the 6th to 8th, causing heavy rains in the central Gulf States and northward to the Ohio Valley and some heavy snow in portions of Iowa and near-by areas, causing blockaded highways and much loss to overhead wires from the clinging snow. Thousands of telephones were put out of operation and communication between some points was possible only by radio.

About the 9th a weak cyclone developed over the west Gulf and during the 10th some heavy rains occurred in the Gulf and South Atlantic States, continuing over much of the same territory during the following day and gradually extending to New England by the 12th, but with diminishing precipitation.

At the morning observation of the 13th two barometric depressions had extended into the Plains region, though but little important precipitation had occurred up to that time. During the following 24 hours the two storms appear to have united and moved to the Great Lakes with increased intensity, and the precipitation area had increased greatly, with high winds on the lower Lakes, the velocity at Buffalo reaching the highest speed ever observed at that place in April and, being from the southwest, drove vast quantities of ice into the eastern end of the lake, raising the general level of the lake in that vicinity by 4 feet or more. Considerable snow occurred in the upper Mississippi Valley and to eastward over the upper Lakes, and heavy rains occurred locally in the west Gulf States and Ohio Valley. This storm moved to the northward of New England by the morning of the 15th, and the rain area extended to the Atlantic coast with heavy local falls in the Southeastern States.

By the 17th stormy conditions had set in over the middle and northern plains, but the rain area was restricted to rather narrow limits in the Lake region, and the storm largely dissipated as it moved eastward toward northern New England.

A storm of small proportions central in the lower Ohio Valley on the morning of the 21st gave some heavy rains over that area and, being reinforced by a secondary depression from the Southwest, developed into an extensive rain area covering a wide territory from the central and southern plains northeastward to the lower Lakes and central New England. The barometric depression was again reinforced over the Southeastern States and precipitation continued on the 24th from the Gulf States to New England, the falls being locally heavy over much of the area, the rain turning to snow in New England and to sleet in a few near-by localities.

One of the most important cyclones of the month originated in the middle plateau about the 24th, but caused little precipitation until the 27th, when the center had reached the middle Gulf States. This storm moved rapidly to the Chesapeake Bay region by the morning of the 28th, when heavy rains were falling along nearly the entire Atlantic coast, and heavy snows had occurred during the preceding night over much of the Allegheny Mountain region, reaching depths up to 18 or 20 inches, the heaviest of record for April in some localities, causing much damage by its heavy, frozen condition to overhead wires, trees, etc. The storm diminished rapidly in strength as it moved to New England during the following day.

The anticyclones were not particularly vigorous and exerted no great influence on the weather save for short periods and moderate areas.

The daily movements of the cyclones and anticyclones are shown on Charts II and III and the monthly distribution of the average pressure and the variations from normal, etc., are shown on Chart VI, and on the insets of Charts II and III.

The winds were not strong over extensive areas, but local storms, doing more or less damage, occurred on numerous dates; some lives were lost and important local property damage resulted from tornadoes which occurred during the month, the usual details of which appear in the table at the end of this section.

TEMPERATURE

Unlike the preceding months of the year, April was unusually cold for the mid-spring month, and while few minimum temperatures were below those recorded in April of previous years, still many sections reported frequent killing frosts and temperatures the lowest of record for so late in the month, and moderate cold was nearly continuous except for the first and last few days. This condition is well illustrated by the remarks of a cooperative observer who summarized the month as having started well and ended well, but having a miserable average.

Generally speaking the cold was not sufficiently severe at any time to cause widespread damage to vegetation, though this was due largely to its dormant condition over areas where the most severe cold occurred.

The first few days were warm and springlike over much of the country, but particularly so in the central valleys on the 2d and further east on the 3d to 5th.

Following this warm spell, colder weather set in over the western sections and the week ending April 10 averaged much colder than normal over all districts from the Mississippi River westward, save for a narrow strip along the immediate Pacific coast where the weekly average was slightly above normal, and it was likewise warmer than average over the eastern third, the excess being quite large in the lower Lake region.

The week ending the 17th continued cold over the interior valleys and to the westward save for the Pacific Coast States, where it continued moderately warm as during the preceding week. Over the eastern districts this week was mostly cold throughout.

With slight variations, the week ending the 24th continued cold throughout, the negative departures being large over all northern districts from the Rocky Mountains eastward, and the weekly averages were also below normal in all other districts, save for small areas in the South and Southeast and at a few points along the coast of southern California.

The last week brought some relief from the long continued period of cold, particularly in the western half where the weekly averages were mainly moderately above normal, and the warmest weather of the month was reported from about the 25th to 30th. Over the eastern half, however, the week as a whole continued cold, some sections of the Southeastern States having minimum temperatures the lowest of record so late in the month.

For the month as a whole the average temperature was below normal in all districts save at a few points on the Atlantic coast, over extreme southern Florida, in portions of Arizona, and locally along the immediate Pacific coast. The monthly means were the lowest of record for April at a few points near the Gulf coast.

The highest temperatures occured mainly from the 2d to 5th over the Great Plains and to eastward, save at a few points in the Gulf States, where they were reported about the 20th to 22d, while from the Rocky Mountains westward they were observed mainly during the last few days.

The lowest temperatures were observed from about the 1st to 3d over the Northeastern States, from the 6th to 9th in the districts from the Rocky Mountains westward, and over the remaining districts from about the 15th to 20th, save a few sections along the South Atlantic coast had their lowest temperatures about the 28th.

PRECIPITATION

The month brought abundant precipitation over nearly all districts from central Kansas, central Oklahoma, and northeastern Texas eastward to the Atlantic coast and over most of the upper Ohio Valley, Middle Atlantic States, and New England.

In portions of the Southeastern States the monthly amounts were the greatest of record for April, and local excessive falls caused more or less flood conditions in parts of Florida and other near-by States. There were local slight excesses in portions of the upper Lake region and near-by Canadian sections, and there were mainly moderate excesses along the Pacific coast from central California to Washington.

In other districts the precipitation was generally less than usually occurs in April, with the least of record for the month occurring locally in Arizona, western Nebraska, and southern Florida. In the southern portions of the latter State an unusual drought has existed for a number of months; in fact at Miami the deficiency dates from October, 1926, since which time to the end of April the total fall has been nearly 40 inches less than usually occurs in such a period. This is the greatest deficiency ever known in that locality for a similar period of time.

SNOWFALL

Some snow fell over unusually wide areas for so late in spring, and the amounts were mainly above the normal for the month in the Lake region, portions of the Appalachian Mountains, Iowa and portions of near-by States, and in some of the mountain States of the West, though in many of these States the fall of snow was less than usual.

Important snows occurred in the upper Mississippi Valley from the 6th to 8th, particularly in portions of Iowa, where traffic was delayed or blocked and much damage resulted to overhead wires by the breaking of poles, etc., from the weight of the heavy frozen snow.

Unusually late snow occurred over north-central Texas about the 14th, and in the central Appalachian Mountain region on the 27th and 28th, the fall being particularly heavy in the Shenandoah Valley in Virginia, where depths up to nearly 20 inches were reported locally, in most cases the greatest fall ever occurring in April, and in some the greatest fall for a single storm in any month.

The general distribution of the snowfall and the monthly amounts over the different areas are shown on Chart VII.

RELATIVE HUMIDITY

Despite the general cloudy rainy conditions over much of the eastern part of the country, the low temperatures favored low relative humidity and the average was below normal over most districts.

Local values in excess of the normal appeared in the Appalachian Mountains, in portions of the Mississippi Valley, and also in the Plateau and Pacific States, where precipitation was generally less than normal.

SEVERE LOCAL STORMS, APRIL, 1928

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau]

Place	Date	Time	Width of path, yards[1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Herbon, Ohio	1		130		$5,500	Tornado	Farm property damaged	Official, U. S. Weather Bureau.
Lincoln, Ark., and vicinity	2	5 p. m.	1,320	3	60,000	do	Considerable property and crop damage; 12 persons injured.	Do.
Page and Fremont Counties, Iowa.	4	3:45 p. m.			4,500	do	Character of damage not reported	Do.
Brown County, Kans	4	4 p. m.	5 mi.		3,000	Hail and wind	Telephone lines and small buildings damaged	Do.
Decatur County, Iowa	4	5 p. m.			400	Tornado	Slight damage	Do.
Monte Ne, Ark	4	5:30 p. m.			6,000	do	Character of damage not reported	Do.
Goldbusk to Santa Anna, Tex.	4	7 p. m.	3,520		312,500	do	60 residences reported demolished	Do.
Bangs, Tex	4	7:45 p. m.	880		5,000	do	Damage chiefly to buildings	Do.
Anoka, County, Minn. (northeast part).	4				100,000	Winds	Damage principally to telephone equipment, barns, and small buildings.	Do.
Fort Worth, Tex	4	P. m.			15,000	Wind and rain	Telephone equipment, an amusement park, and bridges damaged.	Do.
Shawnee, Okla	4	P. m.				Heavy hail	Severe property damage	Do.
Butler, Greenwood, Sumner, Crowley, and Montgomery Counties, Kans.	4	P. m.	75 mi.	1	240,000	Violent winds	Damage chiefly in oil fields	Do.
Kingman County, Kans	5	12:30 a. m.	6-10 mi.		4,000	Heavy hail	Crops damaged	Do.
Wichita, Kans	5	do				Violent wind	Frail buildings damaged	Do.
Hamilton, Iowa	5	4:30 p. m.	1,760		4,000	Hail	Character of damage not reported	Do.
Mahaska, Iowa	5	7 p. m.				Tornado	Buildings damaged	Do.
Austwell, Tex	5					Hail	About one-third of cotton crop destroyed	Do.
Iowa (southwest)	6				700,000	Wind and snow	Wires and poles damaged over an area of 4,000 square miles; highways blocked; traffic and transportation interrupted.	Do.
Nebraska (southeast)	6		85 mi.		300,000	Glaze and snow	Heavy damage to overhead wire systems; traffic interrupted.	Do.
Brownsville, Tex. (near)	8	12:40 p. m.			10,000	Heavy hail	Truck and other vegetation damaged over small area.	Do.
Ola, Ark	13		350		10,000	Tornado	4 persons injured; character of property damage not reported.	Do.
Denver, Colo	18	4-5 p. m.				Whirlwind	Roof damaged; small buildings blown over; fences prostrated.	Do.
Milwaukee, Wis	18-19				5,000	Wind	Plate-glass windows, signs, and awnings damaged.	Do.
Hartford, Conn., and vicinity.	19	P. m.		2		Winds	Many buildings damaged; traffic impeded	Do.
Graves County, Ky	20		4 mi.		35,000	Wind	2 churches, 17 barns, and a number of residences damaged or demolished; path 18 miles long.	Do.
Jacksboro, Tex	20	P. m.			1,000	Tornado	1 residence wrecked; 4 persons injured	Do.
Kershaw and Sumter County, S. C.	20	do			4,000	Hail and wind	Residences, outbuildings, and crops damaged	Do.
Newberry, S. C	20	do			1,000	Heavy hail	Crops injured	Do.
Grapevine, Tex. (near)	20	11 p. m.	100		1,200	Tornado	1 barn demolished; livestock killed	Do.
Edgewood, Tex. (near)	21	12:30 a. m.			2,000	Squall	Trees and roofs damaged	Do.
Terrell, Tex	21	do			20,000	Tornado	1 person injured; property damage chiefly to buildings.	Do.
Mount Vernon, Tex	21	1:30 a. m.			2,500	Squall	Damage mostly to buildings	Do.
Hooks, Tex	21	2 a. m.	5 mi.		15,000	Wind	7 persons injured; character of property damage not reported.	Do.
New Boston, Tex	21	do				Tornado	Several small houses damaged	Do.
Atoka, Tenn	21	2:22 a. m.	200	1	100,000	do	Many homes and trees blown down; wires and poles prostrated; 20 persons injured.	Do.
Linden to Index, Tex	21	2:30 a. m.	1,320	1	100,000	do	Heavy property and crop damage; 43 persons injured.	Do.
Ogden to Red River, Ark	21	3:15 a. m.	3,520		40,000	do	Character of property damage not reported; 1 person injured.	Do.
Memphis, Tenn	21	3:30 a. m.			200,000	Wind	Many buildings damaged; overhead wire systems suffer heavy loss.	Do.
Arp, Tex. (near)	21	3 p. m.	330		10,000	Tornado	Buildings damaged	Do.
Garrard County, Ky	21				20,000	Wind	Several barns and other buildings partly or entirely unroofed.	Do.
Sylvester, Ga	23	4 a. m.	100		5,000	Tornado	Considerable loss of timber	Do.
Brunswick, Ga	23	10:30 a. m.	160		2,000	do	A garage demolished and 5 small houses damaged.	Do.
Tampa, Fla. (near)	23	P. m.				Wind	Considerable damage by water along beach front.	Do.
Little Rock, Ark	23					Thunderstorm	Trees uprooted; signs torn down; wires broken	Do.
Vienna, Ga	23		60		12,000	Tornado	Buildings, household effects, and foodstuff destroyed; some loss of timber.	Do.
Waycross, Ga	27	8 a. m.	16		2,000	do	1 house totally destroyed; a few roofs and porches lifted off.	Do.
Tampa, Fla	27	P. m.				Wind	Roofs, trees, signs, and wires suffer	Do.
Pennsylvania and Maryland (western).	27-28					Wind, snow, and sleet.	Telephone, telegraph, and power lines prostrated; a number of homes unroofed; trees uprooted or broken; transportation delayed.	Do.

[1] "Mi." signifies miles instead of yards.

RIVERS AND FLOODS

By R. E. SPENCER

As shown in the table at the end of this report, floods occurred in the North, Middle, and South Atlantic States, in several streams of the east Gulf, Great Lakes, and Ohio River drainage areas, in the Illinois, Meramec, Arkansas, and White (of Arkansas) Rivers, and in the Williamette River of Oregon; but reports indicate that, excepting those in the South Atlantic and East Gulf States and the Arkansas and White Rivers, the consequences of the rises were in the main unimportant. On the Connecticut and Potomac some inconvenience was experienced, but losses were negligible; on the James unavoidable losses to the extent of $1,000 were reported; in the Raleigh, N. C., district and on the Santee River no damage was done, but advance information of the rise proved of value to logging interests; on the Peedee a $10,000 loss in prospective crops occurred, while property to the value of $100,000 was saved through the flood warnings; and in the Macon, Ga., district a loss estimated at $10,000 resulted from delays to farming and logging operations. In the Great Lakes drainage, where the rises resulted from heavy rains and rapidly melting snow and ice, some farm land was overflowed and other slight damage occurred, while about $3,000 worth of property was saved through flood warnings. Damage in the Ohio drainage was slight, the only specific estimate received giving $2,000 at Pittsburgh, Pa. On the West Fork of the White River of Indiana, however, damage to farm lands overflowed will make considerable reseeding necessary. The Mississippi, Illinois, Meramec, Ouachita, Little Arkansas, and Trinity River rises were well forecast and without consequence. A saving of $6,000 in livestock was effected along the Trinity through the flood warnings.

The more important floods of the Apalachicola, Alabama, Pascagoula, and Pearl Rivers and their tributaries resulted, as did the South Atlantic drainage rises mentioned above, from heavy rains over the East Gulf and South Atlantic States from the 20th to the night of the 22d; and much of the damage was done directly by the rain—in washouts of track, bridges on small streams, highways, newly seeded farm lands, etc.—rather than by overflow from the channels of the larger streams. This was especially true of the Apalachicola system, where the damage to railroads was estimated at $50,000, to highways and bridges on small streams at $225,000, and to prospective crops at $300,000. In the drainage area of the Alabama River, damage was principally of the same kind, an itemized statement showing $8,050 to highways, railroad trackage, etc., $22,700 in prospective and matured crops, $750 in livestock, and $32,000 in suspension of business. There were also five deaths by drowning in small streams. The following note regarding the floods in this district is quoted from the report of the official in charge at Montgomery, Ala.:

> Great damage was done by washing rains and local floods. Early planted crops were ruined over considerable areas. Washouts along the railroads were numerous, and highways were badly injured in places. Hundreds of people were driven from their homes in Brewton, Ala., when flood waters from neighboring creeks inundated parts of the town.

A saving of $165,000 was accomplished through flood warnings in the Montgomery district. In the Pearl and Pascagoula systems the total of reported losses was $58,900, of which $38,500 was in prospective and matured crops, and $10,700 in damage to highways, bridges, and other tangible property. Property valued at $6,500 was saved through Weather Bureau warnings in this district, in addition to a considerable quantity of livestock.

Two rises occurred in the Arkansas and White Rivers of Arkansas—one following the moderate rains of April 4–6 and the other following the heavy rains of April 19–21. In the first, flood stages were not exceeded on the Arkansas proper, but damage to crops was estimated at $94,000, of which $14,000 occurred along the White. In the second flood (following April 21) higher stages and more extensive overflow occurred in both rivers, and along the White damage estimated at $75,000 occurred. On the Arkansas, however, no replanting had been done since the first rise, and the damage did not exceed $10,000. The total saving accomplished through warnings for both these rises is estimated at $118,000.

As on the Arkansas and White Rivers, floods occurred in the Sulphur River of Texas, and moderate rises in the Red River below Springbank, Ark., following the rains of April 4–6 and 19–21 in that section. Losses, chiefly in livestock and due to suspension of business, were estimated at $27,000, while savings to the amount of $45,000 were reported accomplished through the warnings.

River and station	Flood stage	Above flood stage—dates		Crest	
		From—	To—	Stage	Date (all dates in April except as otherwise specified)
ATLANTIC DRAINAGE					
Connecticut:	Feet			Feet	
White River Junction, Vt.	15	6	13	22.0	10
Hartford, Conn.	16	8	14	18.6	10
Potomac: Cumberland, Md.	8	30	[1]	10.4	May 1
James:					
Columbia, Va.	18	28	28	19.7	28
Richmond, Va.	10	29	29	11.5	29
Ronoke: Weldon, N. C.	30	29	[1]	39.2	29
Neuse:					
Neuse, N. C.	15	28	[1]	19.3	30
Smithfield, N. C.	14	29	[1]	16.9	30
Cape Fear:					
Fayetteville, N. C.	35	29	[1]	44.4	29
Elizabethtown, N. C.	22	29	[1]	30.2	30
Haw: Moncure, N. C.	22	28	28	26.0	28
Peedee:					
Cheraw, S. C.	27	29	30	34.0	29
Mars Bluff, S. C.	17	15	19	17.2	18–19
		26	[1]	18.0	30
Lynches: Effingham, S. C.	14	24	24	14.0	24
Black: Kingstree, S. C.	12	25	28	12.3	26–27
Santee:					
Rimini, S. C.	12	[2]	2	12.3	Mar. 30–Apr. 1
		13	[1]	15.4	Apr. 16
Ferguson, S. C.	12	2	3	12.0	2–3
		15	[1]	13.5	28–29
Altamaha:					
Charlotte, Ga.	15	24	[1]	21.2	26
Everett City, Ga.	10	26	[1]	12.0	30
Oconee: Milledgeville, Ga.	22	23	24	26.0	24
Ocmulgee:					
Macon, Ga.	18	23	24	19.8	23
Abbeville, Ga.	11	23	[1]	14.9	29
Lumber City, Ga.	15	24	[1]	17.9	25
EAST GULF DRAINAGE					
Apalachicola:					
River Junction, Fla.	18	23	[1]	26.6	27
Blountstown, Fla.	20	24	[1]	24.6	28
Flint:					
Montezuma, Ga.	20	25	26	21.3	26
Albany, Ga.	20	23	[1]	29.3	24
Bainbridge, Ga.	25	24	[1]	32.7	27
Chattahoochee:					
Eufaula, Ala.	40	24	25	45.0	25
Alaga, Ala.	30	23	27	30.4	24
Alabama:					
Montgomery, Ala.	35	23	28	45.1	25
Selma, Ala.	35	23	[1]	48.0	27
Coosa:					
Lock No. 4, Lincoln, Ala.	17	23	25	19.3	24
Wetumpka, Ala.	45	25	25	46.0	25
Cahaba: Centerville, Ala.	25	21	23	29.5	22
Tombigbee:					
Aberdeen, Miss.	33	24	26	35.4	25
Lock 4, Demopolis, Ala.	39	14	[1]	61.2	May 1
Black Warrior: Lock 10, Tuscaloosa, Ala.	46	22	27	62.5	23

[1] Continued at end of month. [2] Continued from last month.

River and station	Flood stage	Above flood stage—dates From—	Above flood stage—dates To—	Crest Stage	Crest Date (all dates in April except as otherwise specified)
EAST GULF DRAINAGE—continued					
	Feet			*Feet*	
Pascagoula: Merrill, Miss	20	26	29	20.7	27
Chickasawhay:					
Enterprise, Miss	21	23	26	26.0	25
Shubuta, Miss	27	24	29	29.2	28
Leaf: Hattiesburg, Miss	19	24	25	20.3	24
Pearl:					
Edinburg, Miss	21	24	28	23.3	26
Jackson, Miss	20	11	(1)	29.8	30
Monticello, Miss	18	22	28	20.8	23
Columbia, Miss	18	23	(1)	22.9	25
West Pearl: Pearl River, La	13	11	(1)	16.0	28
GREAT LAKES DRAINAGE					
Saginaw: Saginaw, Mich	19	8	11	20.0	9
Tittabawassee:					
Midland, Mich	18	6	9	20.0	8
Shields, Mich	16	8	9	17.4	8
Pine: Alma, Mich	7	4	9	8.0	7
Grand:					
Eaton Rapids, Mich	5	3	11	5.1	9
Grand Rapids, Mich	11	7	10	11.4	8
MISSISSIPPI DRAINAGE					
Allegheny: Lock 5, Freeport, Pa	24	(2)	(1)	---	---
Stony Creek: Johnstown, Pa	10	30	(1)	13.0	30
Youghiogheny: Confluence, Pa	10	30	30	11.0	30
Tuscarawas: Gnadenhutten, Ohio	9	(2)	3	11.4	Mar. 31
		23	24	9.6	23
Walhonding: Walhonding, Ohio	8	22	22	8.2	22
Scioto: Larue, Ohio	11	22	22	11.2	22
Tippecanoe: Norway, Ind	6	2	2	6.0	2
		16	16	6.0	16
White: Decker, Ind	18	26	29	18.6	28
White, West Fork:					
Elliston, Ind	19	23	24	19.5	23
Edwardsport, Ind	15	2	4	15.7	3
		23	26	16.9	24
Tennessee:					
Florence, Ala	18	24	25	18.1	24
Riverton, Ala	33	23	27	37.8	25
Elk: Fayetteville, Tenn	14	22	25	20.1	24
Mississippi:					
Louisiana, Mo	12	14	15	12.1	15
Hannibal, Mo	13	9	16	13.5	14
Illinois:					
Morris, Ill	13	9	9	13.0	9
Peru, Ill	14	1	28	17.0	10
Henry, Ill	10	9	23	11.2	12–14
Havana, Ill	14	10	29	15.1	16–18
Beardstown, Ill	14	10	(1)	16.0	16–18
Pearl, Ill	12	9	27	13.3	18
Meramec:					
Steelville, Mo	12	7	7	14.7	7
Pacific, Mo	11	6	9	20.0	9
Valley Park, Mo	14	6	10	23.0	9
Bourbeuse: Union, Mo	12	6	8	16.4	8
St. Francis: St. Francis, Ark	17	9	19	21.3	12
		22	(1)	21.2	27
Arkansas:					
Fort Smith, Ark	22	23	25	23.4	25
Dardanelle, Ark	20	24	27	21.5	25
Morrilton, Ark	20	24	27	21.0	26
Yancopin, Ark	29	8	(1)	36.5	30
Little Arkansas: Sedgwick, Kans	18	5	5	18.0	5
Petit Jean: Danville, Ark	20	6	10	25.6	7
		22	25	23.5	23
White: Cotter, Ark	21	7	8	22.8	7
		23	25	25.5	24
Calico Rock, Ark	18	6	9	28.8	7
		21	26	31.8	22
Batesville, Ark	23	6	10	32.6	7
		22	26	33.4	22
Newport, Ark	26	8	13	30.3	10
		23	30	32.0	25
Georgetown, Ark	22	10	(1)	28.2	28–29
DeValls Bluff, Ark	24	12	(1)	27.9	30
Clarendon, Ark	30	28	(1)	---	---
Black:					
Poplar Bluff, Mo	14	7	9	16.6	8
		22	25	15.8	23
Corning, Ark	11	7	(1)	13.5	24–28
Black Rock, Ark	14	6	(1)	24.9	22
Cache: Patterson, Ark	9	8	17	9.7	13–14
		23	(1)	9.6	27–29
Tallahatchie: Swan Lake, Miss	25	(2)	10	29.4	Mar. 25–26
		24	(1)	30.6	May 3–4
Sulphur:					
Ringo Crossing, Tex	20	6	9	25.8	6
		22	25	22.4	24
Finley, Tex	24	10	15	25.9	11
		29	30	24.0	29–30

[1] Continued at end of month.
[2] Continued from last month.
[3] Below flood stage at 8 a. m. Apr. 1.

River and station	Flood stage	Above flood stage—dates From—	Above flood stage—dates To—	Crest Stage	Crest Date (all dates in April except as otherwise specified)
MISSISSIPPI DRAINAGE—continued					
Ouachita:	*Feet*			*Feet*	
Arkadelphia, Ark	12	7	8	17.3	8
		22	24	16.0	23
Camden, Ark	30	11	11	30.4	11
		25	28	32.2	27
WEST GULF DRAINAGE					
Trinity: Dallas, Tex	25	5	7	32.4	6
PACIFIC DRAINAGE					
Sacramento: Knights Landing, Calif	18	(3)	1	19.2	Mar. 28–30
Willamette:					
Harrisburg, Oreg	7	(3)	(4)	(4)	(4)
Portland, Oreg	15	1	4	15.5	3

[3] Continued from last month.
[4] Report missing.

MEAN LAKE LEVELS DURING APRIL, 1928

By UNITED STATES LAKE SURVEY

[Detroit, Mich., May 4, 1928]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes [1] Superior	Michigan and Huron	Erie	Ontario
Mean level during April, 1928:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.51	579.52	571.79	246.42
Above or below—				
Mean stage of March, 1928	+0.09	+0.59	+0.29	+0.45
Mean stage of April, 1927	+0.41	+0.72	+0.03	+0.45
Average stage for April, last 10 years	+0.46	−0.12	−0.13	+0.54
Highest recorded April stage	−0.88	−3.71	−2.39	−2.01
Lowest recorded April stage	+1.71	+1.70	+0.98	+1.58
Average departure (since 1860) of the April level from the March level	+0.06	+0.24	+0.54	+0.59

[1] Lake St. Clair's level: In April, 1928, 574.18 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, APRIL, 1928

By J. B. KINCER

General summary.—During the first decade of April, the unusually warm weather advanced fruit trees rapidly in the interior of the country, and at many places they had reached a stage susceptible to frost when a sudden change to cold weather and freezing in many districts occurred. As a result, more or less general damage was done to early fruit over most central trans-Mississippi sections from southern Iowa and Nebraska southward to the northern portions of Arkansas and Oklahoma, and also in northwest and west Texas and New Mexico, the heaviest damage apparently being in the southwestern portion of this area. Elsewhere there was no widespread harm, although some local frosting was reported. The weather was generally favorable in the more eastern States and field operations made good advance, but in the South work was retarded, and cool weather the latter part prevented good growth of vegetation. It was also too cool, cloudy, and wet in the interior valleys, but the Pacific Coast States had favorable weather, although it was generally too cool in the Rocky Mountain districts.

During the second decade the unusually cold, cloudy, windy, and rainy weather in Central and Northern States, with snows in parts, made generally unfavorable conditions for agricultural interests. Tender vegetation was retarded in growth, damaged, or killed by the cold over most of the southern half of the country. Farm work was delayed in most sections east of the Rocky Mountains, with very little corn or cotton planted. Soil moisture was sufficient in most places, however, although extreme southern Florida was still dry and drought continued in parts of the Great Plains and the Southwest.

During the last decade the weather conditions were generally unfavorable for farm interests, especially in the South, although the latter part of the period brought more seasonable temperature conditions in practically all of the eastern half of the country. Growth of all warm weather crops was retarded in the Southeast and field operations were delayed, but considerable work was accomplished in the interior valleys during the latter part. The weather was more favorable over the western half of the country and satisfactory advance of both crops and field operations was noted. Rain was still needed over large areas of the Great Plains southward to the Rio Grande. At the close of the month warm, dry weather was needed in the East and general warm rains over most of the trans-Mississippi area.

Small grains.—During the first part of the month additional moisture was beneficial for winter wheat in the western and southwestern portions of the belt; growth was slow because of cold weather, but conditions continued generally satisfactory. In the Southeast and Atlantic Coast States the weather was favorable and good progress was noted, but in the Ohio Valley area reports continued generally unfavorable, with unusually heavy winterkilling indicated from most sections. Winter wheat made slow progress during the second decade, with deterioration noted in parts of the Southwest. Progress was poor in the upper Mississippi Valley, while in the Ohio Valley little change was noted; in the Atlantic coast area moisture was beneficial. During the last part of the month further deterioration was noted in Nebraska and much of the Ohio Valley area. In Kansas progress continued satisfactory, except in the west, and beneficial rains occurred in western Oklahoma, but in other portions of the Great Plains continued cool, dry weather was detrimental.

A fair amount of spring wheat was seeded during the first decade in parts of the southern belt, but little was accomplished otherwise because of the general cold. Spring oat seeding made fair progress and was well along. During the second decade precipitation was favorable in South Dakota, but conditions were generally unfavorable for seeding. Considerable oats were seeded in the Ohio Valley States, but the cold, wet weather was generally unfavorable for this crop. Toward the close of the month more seasonable weather prevailed over most of the spring wheat belt and better conditions for seeding obtained. The oat crop continued backward in the interior valleys with much still unsown in the Lake region.

Corn.—General rains and cold weather the latter part of the first decade retarded the preparation of soil for corn planting in many interior sections. Some corn was planted as far north as southern Kansas in the West and in the East to North Carolina. In the Southern States there was considerable planting and the early-seeded seemed to have germinated fairly well. During the second decade preparations for corn planting were practically at a standstill in the upper Mississippi and lower Missouri Valleys, but considerable was accomplished in the eastern portion of the belt and in the Atlantic coast area. During the last decade seeding made fair advance in the western half of the belt and eastward to the central Ohio Valley, but farther east the cold, rainy weather retarded field work and but little planting was accomplished. The early seeded in the southern half of the country made poor progress because of unfavorable weather.

Cotton.—In the eastern Cotton Belt much of the first decade was favorable for field work and good progress in planting was reported from the Southeast. It was generally unfavorable for planting west of the Mississippi River, with the low temperatures and high winds especially detrimental in Texas. The second decade was decidedly unfavorable in the Cotton Belt, and only a small amount of cotton was planted, while the early seeded either deteriorated or made very slow progress, with much of it reported killed in central, northern, and western Texas and parts of Arkansas. In the more eastern portions of the belt conditions were somewhat better, with fair germination indicated. The first part of the last decade was very unfavorable in the eastern part of the belt, but there was some improvement toward the close. In Texas the cool nights, windy weather, and dryness were detrimental, with progress and condition of the crop poor to only fair. It was also too cool and wet in Oklahoma, with slow progress in planting and indications of poor germination.

Miscellaneous crops.—Pastures and meadows were greening rather generally in the East during the first decade, but the weather was too cool for growth of grass in the Great Plains area. Precipitation was of benefit in parts of the Southwest, but slow growth was reported from some western portions. Cold weather was unfavorable for livestock in the West, especially for lambing and shearing. During the second decade pastures showed some improvement in the Southeast and ranges were greening slowly in the Great Plains and affording some feed. Cold weather delayed growth of range forage in some western parts, and lambing and farrowing were also unfavorably affected by coolness. During the last decade pastures did fairly well in most of the South, but in northern parts growth was slow and rains would have been beneficial in the Great Plains. Precipitation was needed in parts of the Southwest, but shearing and lambing were favored.

Potato planting had progressed northward to Wisconsin and South Dakota at the close of the month and mostly satisfactory advance of the crop was reported, except for some injury by freezing from North Carolina westward to Arkansas during the latter part of the month. There was considerable damage by the low temperatures to tender vegetation from Maryland to Arkansas during the second decade, with all tender truck reported killed in northern and western Texas. Truck made generally satisfactory advance in most other portions. Cold weather damaged early fruit bloom during the second decade in middle Atlantic sections and also in Tennessee and Arkansas, but in the main peach sections of the Southeast, including North Carolina, there was no material harm.

108217—28——3

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

Taking the ocean as a whole, April should not be considered an unusually stormy month, although the number of days with gales was considerably above the normal along the American coast and over the steamer lanes east of the forty-fifth meridian. Heavy weather between the forty-fifth and sixtieth meridians was comparatively rare, however, and the great majority of the gales reported would be classed as moderate.

Fog was reported on 13 and 15 days, respectively, along the New England coast and over the Grand Banks, which in both cases was above the normal. Fog was also observed on from 2 to 3 days over the middle eastern sections of the steamer lanes and on 1 day in the western part of the Gulf of Mexico.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian), North Atlantic Ocean, April, 1928*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Isle, Newfoundland	29.78	−0.05	30.46	7th	29.18	26th.
Halifax, Nova Scotia	29.94	+0.05	30.56	3d	29.50	25th.
Nantucket	29.94	−0.04	30.54	3d	29.26	24th.
Hatteras	30.04	+0.03	30.48	3d	29.48	28th.
Key West	30.02	0.00	30.22	1st [2]	29.80	11th.
New Orleans	30.01	+0.01	30.34	1st	29.72	22d.
Cape Gracias, Honduras	29.91	−0.06	30.04	4th	29.84	10th.
Turks Island	30.10	+0.08	30.16	2d [2]	29.90	7th.
Bermuda	30.15	+0.15	30.36	21st	29.90	8th.
Horta, Azores	30.09	−0.02	30.40	21st [2]	29.52	17th.
Lerwick, Shetland Islands	29.80	0.00	30.22	14th	29.18	3d.
Valencia, Ireland	29.73	−0.16	30.19	17th	29.08	10th.
London	29.80	−0.07	30.28	23d	29.46	10th.

[1] From normals shown on Hydrographic Office Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m. seventy-fifth meridian.
[2] And on other dates.

On the 2d a severe disturbance of limited extent was central near 55° N., 27° W.; this moved northeastward and on the 3d was off the south coast of Ireland.

On the 5th and 6th Bermuda was near the center of a LOW that remained nearly stationary, gradually filling in. On the 6th there was also a well-defined depression in the Gulf of Mexico that by the morning of the 7th had practically disappeared.

Charts VIII to XI show the conditions from the 7th to the 10th, inclusive, when the middle and eastern sections of the steamer lanes were swept by heavy gales.

On the 11th a LOW was central near Charleston that moved northeastward and on the 12th was off the coast of Maine. On both dates moderate to strong gales prevailed over the region between Hatteras and Nova Scotia.

On the 12th and 13th a storm area of limited extent was over the middle section of the steamer lanes, while by the 14th moderate weather was the rule over practically the entire ocean.

On the 15th and 16th a disturbance covered a portion of the southern steamer lanes, and on the latter date northwest gales were reported between the thirtieth and thirty-fifth parallels and the thirty-fifth and forty-fifth meridians. On the 16th northeasterly gales also occurred along the American coast between Charleston and Hatteras.

From the 19th to the 23d unfavorable conditions prevailed over the greater part of the steamer lanes, the storm areas reaching their greatest intensity and extent on the 20th and 23d; on the former date extending from the twenty-fifth to sixty-fifth meridians and on the latter, from the fifteenth to forty-fifth.

On the 25th Pensacola was near the center of a LOW that moved rapidly northeastward and on the 24th was central near Eastport, with moderate to strong gales over the region between Nantucket and the Bermudas.

From the 25th to 27th favorable weather prevailed generally, except that on the 27th a moderate disturbance was off the coast of southern Europe and there was a depression in the Gulf of Mexico that afterwards developed into a severe disturbance as it moved northeastward. On the 28th this LOW was over the Virginia Capes, with strong gales between the thirtieth parallel and Hatteras. On the 29th the center was near Portland, Me., with the storm area remaining of about the same extent as on the previous day.

OCEAN GALES AND STORMS, APRIL, 1928

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Sagaporack, Am. S. S.	Norway	Portland, Me.	56 20 N.	24 40 W.	Apr. 2	8 a., 2	Apr. 2	28.44	SW	SW., —	WSW	WSW., 9	SW.-WSW.
Brave Coeur, Am. S. S.	Galveston	Bremen	32 64 N.	64 28 W.	5	—, 6	6	29.87	NNE	NNE., 7	NE	NNE., 8	
Sylvan Arrow, Am. S. S.	Beaumont	Boston	27 30 N.	89 10 W.	5	4 a., 6	6	29.76	SSE	SSE., 7	NE	SSE., 8	SSE.-S.-WNW. NE.
Bannack, Am. S. S.	Liverpool	do	49 05 N.	33 50 W.	3	Noon, 7	8	28.84	W	NW	N	NW., 11	W.-NW.-N.
Wytheville, Am. S. S.	Rotterdam	New York	48 56 N.	32 56 W.	7	11 a., 7	8	28.88	WNW	W	N	—, 12	N.-NW.
Mercer, Am. S. S.	New York	Rotterdam	45 20 N.	27 35 W.	6	—, 8	9	29.05	NW	NW., 9	NW	NW., 11	WNW.-NW.
Sylvafield, Br. S. S.	Rouen	Colon	47 40 N.	10 38 W.	8	7 a., 8	8	29.00	SSE	SSE., 9	SW	SSE., 9	SSE.-SW.
Jeff Davis, Am. S. S.	Houston	Bremen	28 05 N.	91 42 W.	9	10 a., 9	9	29.58	NE	N., 8	NE	N., 8	NE.-N.-NE.
Tulsa, Am. S. S.	Antwerp	Charleston	32 54 N.	73 30 W.	10	Noon, 10	11	29.65	S	S, 7	SW	SSW., 12	
Vincent, Am. S. S.	New York	Havre	47 40 N.	24 51 W.	7	4 a., 10	11	29.50	NW	WNW., 9	WNW	NW., 11	WNW.-NW.
Bussum, Du. S. S.	Rotterdam	Russia	56 46 N.	4 08 E.	11	4 a., 11	11	29.52	E	E	E	E., 9	Steady.
Cyrus Field, Br. S. S.	Halifax	Cable repairs			11	8 p., 12	12	29.53	SE	S., 3	SSE	SSE., 9	
United States, Dan. S. S.	do	Christiansand	52 50 N.	29 45 W.	13	3 a., 14	14	29.19	N	NNE., 8	NE	N., 9	N.-NE.
Liberty Glo, Am. S. S.	Savannah	Liverpool	51 45 N.	8 15 W.	14	2 p., 14	15	29.44	E	E., 10	E	E., 10	Steady.
Western Queen, Am. S. S.	Galveston	Bremen	40 05 N.	48 15 W.	14	4 a., 15	15	29.67	NNW	NW	NW	—, 10	Do.
City of Flint, Am. S. S.	Hull	Philadelphia	52 00 N.	34 00 W.	19	4 a., 19	23	29.63	WSW	—, 7	WNW	—, 10	
Berlin, Ger. S. S.	Cherbourg	New York	41 45 N.	61 00 W.	19	8 a., 20	20	29.56	SW	SW., 10	WNW	SW., 10	SW.-WNW.
Tuscarora, Br. S. S.	New York	London	47 08 N.	27 42 W.	21	10 p., 22	23	29.45	SSW	SW., 4	SW	WSW., 9	S.-WSW.
Sylvan Arrow, Am. S. S.	Boston	Beaumont	27 31 N.	88 29 W.	22	6 a., 23	23	29.68	SE	SSW., 8	NW	SSW., 8	SSW.-WNW.
San Jacinto, Am. S. S.	New York	Galveston	29 56 N.	77 28 W.	23	8 p., 23	23	29.40	SSW	SSE., 10	SSW	SSE., 10	SSW.-SSE.
Western Ally, Am. S. S.	Rotterdam	New York	45 28 N.	36 10 W.	23	6 a., 23	23	29.51	SW	WNW., 11	NW	WNW., 11	
Stockholm, Swed. S. S.	Gothenburg	do	55 18 N.	21 18 W.	23	8 p., 23	24	28.68	SSE	S., 9	W	S., 9	SSE.-WSW.
Sangamon, Am. S. S.	Casablanca	do	35 30 N.	68 58 W.	24	4 a., 24	24	29.62	SW	SW., 7	NW	SW., 9	SW.-NW.
Lorain, Am. S. S.	Portland, Me.	Hamburg	48 55 N.	18 50 W.	26	4 p., 26	27	29.77	N	NNE., 8	N	NE., 9	N.-NNE.-N.
Murex, Br. S. S.	New Orleans	Southampton	29 30 N.	79 40 W.	27	8 p., 27	29	29.57	S	W., 8	NW	W., 11	SW.-WNW.
Cananova, Am. S. S.	New York	West Indies	38 58 N.	74 00 W.	27	3 a., 28	29	29.29	E	E., 6	WNW	E., 11	E.-S.-SSW.
Steel Seafarer, Am. S. S.	Algeria	New York	35 45 N.	0 39 W.	29	7 a., 29	29	29.85	W	W., 8	W	W., 9	Steady.
NORTH PACIFIC OCEAN													
Bearport, Am. S. S.	Hong Kong	San Francisco.	41 07 N.	132 50 W.	Apr. 1	7 p., 1	Apr. 2	29.38	W	W., 8	WNW	W., 8	W.-NW.
West Cayote, Am. S. S.	Dairen	Portland	32 18 N.	133 54 E.	1	4 p., 2	5	29.75	NE	NNW., 9	NNW	NNW., 9	
Antietam, Am. S. S.	Yebisu, Japan.	San Pedro	38 04 N.	155 08 W.	4	3 a., 5	5	30.00	N	N., 9	NNW	N., 9	N.-NNW.
Pres. Jackson, Am. S. S.	Victoria	Yokohama	45 07 N.	157 29 E.	5	8 p., 5	6	28.63	SE	SSE., 7	NW	—, 10	NNW.-NW.
West Hixton, Am. S. S.	Kobe	Portland	40 10 N.	153 12 E.	5	2 p., 5	6	29.06	WNW	WNW., 7	W	NW., 10	NW.-W.
Havre Maru, Jap. S. S.	Yokohama	San Francisco.	45 07 N.	142 55 W.	7	4 p., 7	7	29.58	ESE	SE., 8	SW	SE., 8	ESE.-SE.
Yankee Arrow, Am. S. S.	Shanghai	San Pedro	31 50 N.	133 00 E.	15	2 p., 15	16	29.54	NE	SSE., 10	N	NE., 11	NE.-SSE.
Point Lobos, Am. S. S.	Balboa	do	15 34 N.	96 55 W.	16	11 a., 16	17	29.93	NW	—, 5	N	NE., 9	8 pts.
Tecumseh, Br. S. S.	Yokohama	San Francisco.	34 50 N.	142 43 E.	19	4 a., 20	20	29.88	S	SW., 7	SW	SSW., 9	S.-SSW.
West Togus, Am. S. S.	Manila	do	41 46 N.	162 30 W.	20	10 p., 20	21	29.93	W	W., —	NW	WNW., 9	W.-NW.
Kinkasan Maru, Jap. S. S.	Anacortes	Yokohama	50 37 N.	177 40 W.	21	21	23	29.39	SW	WNW., 8	NW	W., 10	WNW.-W.
West Sequana, Am. S. S.	Yokohama	San Francisco.	37 00 N.	145 30 E.	22	8 a., 23	25	29.20	ESE	SW., 9	NW	SW., 9	S.-WSW.
West Prospect, Am. S. S.	Otaru	do	41 40 N.	145 00 E.	23	23	25	28.67	ENE	NNE., 10	WNW	NE., 11	NE.-NNW.
Tecumseh, Br. S. S.	San Francisco.	Nagasaki	31 45 N.	161 49 W.	23	6 a., 23	24	29.36	WSW	W., 7	N	NNE., 10	W.-NNE.
West Niger, Am. S. S.	Columbia River.	Fushiki	41 08 N.	140 10 E.	23	2 p., 23	24	29.21	N	NW., 4	NNW	NNW., 10	NW.-NNW.
West Kader, Am. S. S.	Dairen	Portland	47 40 N.	134 36 W.	23	6 a., 24	25	29.46	SSW	S., 8	SSE	S., 9	SSW.-S.
Juyo Maru, Jap. S. S.	Miikie	Coos Bay	45 34 N.	134 00 W.	24	3 a., 25	25	29.50	SSE	SSE. —	SSE	SSE., 9	Steady.
West Sequana, Am. S. S.	Yokohama	San Francisco.	44 05 N.	174 22 E.	29	4 p., 29	29	29.83	SSE	SSW., 9	WSW	SSW., 9	SSE.-S.-SW.
Pres. Grant, Am. S. S.	Seattle	Yokohama	48 21 N.	169 49 E.	29	8 a., 29	30	28.73	ESE	SW., 10	WNW	SW., 11	SW.-WNW.
West Prospect, Am. S. S.	Otaru	San Francisco.	46 36 N.	171 45 E.	29	29	May 1	29.39	SSE	S., 10	W	SW., 10	S.-SW.
SOUTH PACIFIC OCEAN													
West Nivaria, Am. S. S.	Lyttelton, N. Z.	do	30 45 S.	175 40 W.	3	11 p., 3	4	29.24	ENE	SE., 10	SSE	SE., 11	E.-SSE.
San Nazario, Br. S. S.	San Pedro	Montevideo	47. 55 S.	79 15 W.	17	3 p., 18	19	28.78	NNW	NW., 11	WSW	NW., 11	NW.-WNW.
Hauraki, Br. M. S.	Sydney	Vancouver	25 20 S.	164 57 E.	18	4 p., 20	20	30.00	S. E	E. S.E., 8	ESE	SE., 10	
SOUTH ATLANTIC OCEAN													
Rathlin Head, Br. S. S.	Glasgow	Montevideo	34 41 S.	53 55 W.	10	4 p., 10	11	29.45	WSW	WSW., 6	W	WSW., 9	None.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The Aleutian cyclone continued, being very active for the season, with pressure below the normal over its entire area, and with the center still over the western part of the Gulf of Alaska and the adjacent peninsula, as in March. Separate LOWS from this northern base entered the American mainland north of the forty-fifth parallel on 10 dates. The north Pacific anticyclone was also in the main well developed, being practically normal in average pressure, and having fewer cyclonic intrusions than usual for the season.

Pressure data for several island and continental stations in west longitudes are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, April, 1928*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1]	29.64	−0.19	30.50	6th	28.86	26th.
St. Paul [1] [2]	29.73	−0.07	30.66	6th	28.84	22d.
Kodiak [1] [2]	29.57	−0.23	30.14	8th	29.00	20th.
Midway Island [1] [3]			30.26	29th	29.80	7th.
Honolulu [4]	30.04	−0.03	30.13	22d	29.92	8th.
Juneau [4]	29.84	−0.12	30.57	6th	29.34	27th.
Tatoosh Island [4] [5]	29.96	−0.08	30.56	6th	29.34	2d.
San Francisco [4] [5]	30.06	+0.02	30.20	18th	29.83	2d.
San Diego [4] [5]	29.97	+0.01	30.14	9th	29.77	28th.

[1] P. m. observations only.
[2] For 27 days.
[3] 9 days missing; average not used.
[4] A. m. and p. m. observations.
[5] Corrected to 24-hour mean.

Gales decreased in numbers and general intensity since March, this being especially true of the eastern half of the ocean. The majority of those experienced in west longitudes attained a force no higher than 8 or 9, though the maximum, occurring on three days, was force 10, as shown by the gale reports. Along the upper half of the routes between the west coast of the United States and Honolulu moderate gales were encountered by vessels on the 1st, 2d, 15th, 24th, and 25th. A norther of force 9 occurred off the southern coast of Mexico on the 16th.

Stormier conditions prevailed over the upper western half of the ocean. This was in part due to the unsettled weather conditions existing in Asiatic waters. The continental anticyclone broke up to a great extent over China and the neighboring waters. In consequence the northeast monsoon current became enfeebled and at the end of the month had wholly disappeared, while a number of depressions, most of them of a minor character, gathered over southern waters. Some, however, developed local intensity, and one became a violent storm. This originated on the 21st in the Eastern Sea. It developed with rapidity, causing strong gales over southern and central Japan and adjacent waters on the 22d, and over central and northern Japan on the 23d, on which date the strongest gales occurred at sea, full storm winds being experienced off the northeastern part of the archipelago. Other gales of force 11 occurred south of Japan on the 15th, in connection with a moderate depression there, and on the 29th, near 48° N., 170° E., at which time a large area southwest of the Aleutians was swept by gales.

At Honolulu the wind continued to prevail from the east, but with average velocity the lightest on record for April. The maximum velocity was at the rate of 26 miles an hour from the east on the 30th.

It was observed in March that fog was beginning to form more actively in east longitudes, especially along the upper sailing routes and in the coastal waters of China. A far greater increase occurred over this region in April, the percentage of days with fog rising, from the 5 to 10 per cent maximum of the previous month, to one of 20 to 30 per cent in the present month. Fog also occurred on several days in the Eastern and Yellow Seas. A report from the American steamer *Dickenson*, Midway Island to Honolulu, from March 31 to April 5, said: "Fog has been encountered almost every morning and evening, coming up from the SE. or S. in low-moving masses." Scattered fog was met with in west longitudes, but was not frequent even along the American coast, although reported to and slightly below the twentieth parallel. Observers Slayton and Ihle, of the American motor ship *William Penn*, saw fog on the 15th in 17° 27′ N., 116° 26′ W. Quoting from their report:

> At 3.50 a. m. * * * moderate north wind and sea. Weather clear and cloudy. Air temperature, 70°; sea, 74°. A large rainbow was sighted ahead; 3.55 a. m., ship ran into very heavy fog, obstructing moon and stars; 4.05 a. m., 10 minutes later, fog lifted just as suddenly as it came.

Waterspouts were reported off the coast of Costa Rica on the 23d and 29th.

CLIMATOLOGICAL TABLES [1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, April, 1928

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	59.8	−3.7	Selma	89	[2] 5	Riverton	28	16	9.86	+5.57	Coffee Springs	16.86	Riverton	4.97
Arizona	59.5	−0.1	Gila Bend	104	27	Bright Angel Ranger Station.	6	5	0.20	−0.45	Blue	1.22	36 stations	0.00
Arkansas	57.3	−4.1	3 stations	87	[2] 1	Dutton	22	[2] 10	8.52	+3.64	Huttig	14.01	Amity	4.03
California	55.6	−0.4	Greenland Ranch	108	30	Helm Creek	−16	6	1.46	−0.23	Crescent City	13.03	16 stations	0.00
Colorado	41.4	−1.3	Wray	89	[2] 4	Echo Lake	−19	8	1.00	−0.94	La Veta Pass	6.77	Blanca	T.
Florida	68.5	−1.3	Brooksville	95	22	4 stations	35	[2] 1	7.47	+4.83	Bonifay	20.25	Fort Pierce	0.25
Georgia	61.3	−2.1	Valdosta	89	20	2 stations	27	17	8.07	+4.49	Blakely	14.85	Blue Ridge	4.02
Idaho	42.5	−2.1	4 stations	86	[2] 25	Big Springs	−16	7	1.46	−0.14	Bungalow	6.77	Sugar	T.
Illinois	48.6	−3.8	Greenville	83	2	Mount Carroll	15	15	3.34	−0.07	New Burnside	7.13	Minonk	1.73
Indiana	48.0	−4.0	Cambridge City	84	3	Marengo	17	10	2.95	−0.54	Evansville	5.23	Huntington	0.67
Iowa	44.3	−4.6	Oakland	88	2	Mason City	6	15	2.24	−0.72	Afton	4.37	Sioux City	0.22
Kansas	51.6	−2.1	Salina	93	2	Oberlin	10	14	2.34	−0.20	Newton	7.45	Phillipsburg	0.08
Kentucky	52.9	−3.0	Williamsburg	83	2	2 stations	21	16	4.20	+0.17	Mayfield	7.48	Munfordville	1.28
Louisiana	63.0	−4.0	Donaldsonville	91	20	2 stations	30	[2] 14	6.82	+2.12	Robeline	11.81	Lake Charles	2.36
Maryland-Delaware	50.0	−2.5	3 stations	85	5	Oakland, Md.	14	16	5.86	+2.50	State Sanatorium, Md.	8.37	Takoma, Md.	4.27
Michigan	39.1	−3.7	Five Channels	79	4	Humboldt	−11	20	2.99	+0.52	Charlevoix	5.75	St. Joseph	0.78
Minnesota	37.0	−5.6	Gull Lake Dam	88	1	Fosston	0	19	2.01	+0.02	Red Wing	4.80	Hallock	0.35
Mississippi	60.7	−3.6	2 stations	89	[2] 20	Pontotoc	29	16	8.93	+3.74	Monticello	14.42	Hernando	4.85
Missouri	51.6	−3.5	Tarkio	88	2	Unionville	16	15	4.79	+1.06	Koshkonong	9.43	Kidder	1.01
Montana	39.6	−2.8	Winifred	88	29	Hebgen Dam	−11	8	0.91	−0.24	Columbia Falls	3.46	Foster	0.08
Nebraska	46.4	−2.6	3 stations	92	[2] 2	2 stations	1	8	0.46	−1.98	Auburn	4.01	6 stations	0.00
Nevada	47.2	−1.2	Logandale	100	29	2 stations	8	8	0.41	−0.40	Hylton	1.92	7 stations	0.00
New England	41.3	−2.4	2 stations	84	5	Somerset, Vt.	−17	1	4.16	+0.93	Machias, Me.	7.81	Bethlehem, N. H.	1.32
New Jersey	47.4	−1.9	South Orange	85	5	Runyon	16	3	5.26	+1.64	Tuckerton	7.16	New Milford	3.82
New Mexico	49.2	−1.3	Lakewood	99	30	2 stations	−14	9	0.77	−0.29	Gallinas Planting Station.	3.51	5 stations	0.00
New York	41.8	−2.6	Voorheesville	92	5	Indian Lake	−7	2	3.61	+0.73	High Falls	7.84	Chazy	0.58
North Carolina	55.8	−2.0	2 stations	85	[2] 5	Mount Mitchell	8	28	5.91	+2.04	Mount Mitchell	10.58	Cullowhee	3.33
North Dakota	35.9	−5.8	Minot	84	28	Eckman	−6	19	0.88	−0.50	Mott	2.30	Westhope	0.08
Ohio	46.5	−3.5	Middleport	85	6	2 stations	16	16	3.06	−0.29	Wilmington	4.63	Put-in-Bay	1.65
Oklahoma	57.3	−2.4	Hobart	97	17	Boise City	17	13	4.86	+0.76	Tuskahoma	13.30	Kenton	0.82
Oregon	46.6	−1.5	2 stations	88	[2] 9	Fremont	7	7	3.23	+0.94	Valsetz	16.45	Bend	0.06
Pennsylvania	46.0	−2.8	Bradford	88	7	2 stations	11	16	5.50	+2.13	Somerset	9.82	Sharon	2.11
South Carolina	59.9	−2.4	Marion	89	3	Cherokee (near)	28	16	6.40	+3.33	Camden	10.65	Charleston	2.54
South Dakota	41.1	−4.4	Menno	86	2	Watertown	−5	14	0.87	−1.20	Dumont	2.92	Fairfax	0.10
Tennessee	55.5	−3.1	Copperhill	85	5	Crossville	22	16	6.01	+1.49	Sewanee	9.45	Nashville	3.22
Texas	62.6	−3.4	Ricardo	106	21	Dalhart	18	9	2.15	−1.10	Jefferson	10.47	3 stations	0.00
Utah	45.5	−1.3	St. George	94	30	Fruitland	4	8	0.65	−0.67	Manila	3.00	4 stations	0.00
Virginia	52.4	−2.2	Woodstock	87	6	Burkes Garden	17	16	4.88	+1.53	Massinaccac	7.23	Fredericksburg	2.85
Washington	45.8	−1.9	Alpowa Ranch	84	26	Stockdill Ranch	12	7	3.68	+1.17	Cougar	17.76	2 stations	0.42
West Virginia	48.6	−3.2	3 stations	88	[2] 5	2 stations	11	16	5.08	+1.38	Bayard	8.00	Union	2.57
Wisconsin	38.0	−5.4	Prairie du Chien	79	4	Rest Lake	−20	15	2.42	−0.13	Eau Claire	4.47	2 stations	1.37
Wyoming	38.0	−2.2	Dull Center (near)	87	27	Dome Lake	−23	8	0.72	−0.74	Dome Lake	2.92	Dubois	0.00
Alaska [*March*]	9.5	−4.9	Hydaburg	64	19	Allakaket	−56	18	1.86	+0.19	Ketchikan	23.87	White Mountain	T.
Hawaii	71.9	+1.6	Mahukona	91	7	Volcano Observatory.	50	21	6.76	−1.50	Wahiawa Water Co. (intake).	32.80	Mahukona	0.13
Porto Rico	75.4	+0.2	2 stations	93	8	Toro Negro	54	11	1.87	−2.88	San Sebastian	8.15	Coroza	0.16

[1] For description of tables and charts, see REVIEW, January, 1928, p. 43.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1928*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind (3-cup anemometer used): Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							42.7	−1.2										71	3.79	+0.8										5.7		
	76																															
Eastport	1,070	67	85	29.80	29.89	−.04	38.6	−0.4	56	7	45	24	16	32	24	35	31	75	2.14	−0.7	12	8,157	s.	48	ne.	24	3	12	15	7.3	1.5	0.0
Greenville, Me.	103	6		28.70	29.88		35.1		73	6	44	9	2	26	36				3.87		16		nw.				6	5	19		26.2	
Portland, Me.	280	82	117	29.81	29.94	−.02	41.2	−1.8	70	8	49	25	2	34	27	37	31	69	4.96	+1.6	13	7,132	nw.	28	s.	3	15	5	10	4.7	1.7	0.0
Concord	403	70	79	29.60	29.92	−.07	42.0	−1.4	82	6	53	20	2	31	48				3.55	+0.8	12	5,241	w.	29	w.	9	13	7	10	5.2	14.1	0.0
Burlington	876	11	48	29.46	29.91	−.08	39.8	−3.5	77	6	48	16	2	32	38				2.07	−0.1	12	7,668	nw.	54	s.	3	3	7	20	7.4	0.4	0.0
Northfield	125	12	60	28.96	29.93	−.06	37.0	−3.3	78	6	47	5	2	27	42	33	29	73	3.30	+1.3	13	5,352	s.	35	sw.	8	4	10	16	7.1	11.9	0.0
Boston	12	115	188	29.79	29.93	−.04	46.8	+0.4	84	5	56	28	16	38	42	40	33	64	4.68	+1.3	11	7,807	w.	27	sw.	25	11	9	10	5.2	T.	0.0
Nantucket	26	14	90	29.92	29.93	−.04	43.7	+0.3	62	7	49	30	2	38	18	40	36	77	3.44	+0.8	11	12,600	sw.	48	ne.	11	12	11	7	5.0	0.0	0.0
Block Island	160	11	46	29.90	29.93	−.05	43.9	−0.1	60	19	49	30	16	38	18	40	36	77	3.07	+0.4	12	13,837	sw.	54	ne.	11	5	15	10	5.8	0.2	0.0
Providence	159	215	251	29.70	29.94	−.04	45.4	−1.2	81	5	54	26	2	37	39	39	32	64	3.69	+0.5	15	9,418	nw.	52	nw.	25	9	14	7	5.1	T.	0.0
Hartford	106	122		29.78	29.95	−.04	45.6	−1.1	77	5	55	26	2	36	34				4.71	+1.4	13		s.				11	9	10	5.0	T.	0.0
New Haven		74	153	29.84	29.96	−.03	45.8	−1.4	77	19	55	28	2	37	34	41	36	72	5.11	+1.6	12	7,535	sw.	38	w.	19	9	15	6	5.1	T.	0.0
Middle Atlantic States							45.5	−1.8										66	5.36	+2.0										5.7		
Albany	97	102	115	29.84	29.94	−.06	44.8	−2.0	82	5	54	24	2	36	35	38	31	64	3.29	+0.8	14	5,327	sw.	29	s.	3	10	11	9	5.3	3.1	0.0
Binghamton	871	10	84	28.90	29.94	−.08	43.3	−2.1	81	5	53	23	16	34	35				4.73	+2.5	15	5,266	w.	30	w.	8	8	7	15	6.3	7.5	0.0
New York	314	414	454	29.62	29.96	−.04	47.5	−1.9	77	5	56	28	16	39	35	41	33	61	4.71	+1.5	11	13,187	nw.	61	nw.	19	8	10	12	6.2	T.	0.0
Harrisburg	374	94	104	29.57	29.97	−.05	48.0	−2.9	80	5	57	28	16	39	34	41	33	60	6.22	+3.7	10	5,998	w.	34	sw.	19	7	10	13	6.1	2.4	0.0
Philadelphia	114	123	341	29.85	29.98	−.03	50.6	−1.5	81	19	59	31	16	42	36	44	38	68	5.55	+2.5	10	8,875	w.	47	ne.	27	10	9	11	5.9	1.0	0.0
Reading	325	81	98	29.61	29.96		49.0		81	5	58	29	16	40	37	41	33	58	5.95	+2.7	11	5,470	w.	31	sw.	19	12	10	8	5.3	3.0	0.0
Scranton	805	111	119	29.08	29.96	−.05	45.2	−2.9	80	5	55	25	16	35	38	40	34	70	5.03	+2.4	13	6,136	s.	38	sw.	19	10	6	14	6.0	2.2	0.0
Atlantic City	52	37	172	29.91	29.97	−.06	47.6	−0.2	70	19	54	30	16	41	24	43	38	73	6.87	+3.9	11	13,794	w.	72	ne.	28	12	10	8	4.7	T.	0.0
Cape May	17	13	49				49.2	+0.8	72	19	57	30	17	41	26	45	41	77	4.17		14		nw.				14	5	11		T.	0.0
Sandy Hook	22	10	55	29.93	29.95		47.1		75	5	54	31	16	40	30	41	35	68	4.26		11	12,121	w.	50	ne.	28	8	10	12	5.7	T.	0.0
Trenton	190	159	183	29.76	29.96		48.2		79	5	58	28	16	39	38	43	37	71	4.67	+1.4	12	9,182	w.	41	e.	28	9	9	12	5.8	1.2	0.0
Baltimore	123	100	215	29.84	29.97	−.04	51.9	−1.7	84	19	61	31	16	43	35	44	38	64	6.26	+2.9	12	8,629	sw.	46	sw.	19	9	9	12	5.7	T.	0.0
Washington	112	62	85	29.85	29.97	−.05	51.9	−1.4	84	19	62	29	16	42	37	44	36	60	4.49	+1.2	9	5,865	nw.	28	w.	19	11	7	12	5.7	T.	0.0
Cape Henry	18	8	54	29.96	29.98		56.0		84	22	65	35	17	47	32	50	44	68	3.80	+0.5	10	9,430	sw.	38	nw.	23	13	6	11	4.9	0.0	0.0
Lynchburg	681	153	188	29.24	29.98	−.04	53.2	−4.1	80	4	64	29	16	42	34	46	40	64	4.55	+1.6	10	6,635	sw.	28	s.	7	11	8	11	5.5	0.0	0.0
Norfolk	91	170	205	29.90	30.00	−.01	56.6	−0.2	80	22	67	37	16	47	30	49	42	65	4.24	+1.0	10	10,210	s.	40	sw.	19	11	8	11	5.1	0.0	0.0
Richmond	144	11	52	29.84	29.99	−.03	54.2	−2.4	82	4	65	31	16	43	35	47	41	68	6.86	+3.4	14	7,100	sw.	34	sw.	14	12	6	12	5.5	0.0	0.0
Wytheville	2,304	49	55	27.59	29.98	−.05	49.0	−3.0	71	4	58	25	16	40	29	42	37	70	3.35	+0.4	16	5,418	w.	26	w.	7	5	13	12	6.5	1.8	0.0
South Atlantic States							60.2	−1.7										71	6.00	+3.0										5.3		
Asheville	2,253	70	84	27.62	29.98	−.05	52.0	−1.9	75	2	62	27	16	42	35	45	39	68	4.53	+1.3	14	7,023	se.	29	s.	7	10	9	11	5.8	2.3	0.0
Charlotte	779	55	62	29.16	30.00	−.03	57.2	−2.6	79	6	68	32	16	47	30	50	44	69	5.87	+2.6	11	4,252	sw.	25	sw.	7	6	12	12	6.3	T.	0.0
Hatteras	11	11	50	30.00	30.01	.00	60.2	+0.4	76	21	67	41	16	54	25	56	52	77	9.25	+5.7	10	10,706	sw.	38	s.	27	14	8	8	4.3	0.0	0.0
Raleigh	376	103	110	29.60	30.01	−.02	56.8	−2.6	80	22	67	32	16	46	33	51	47	76	5.50	+2.0	11	6,246	sw.	33	nw.	22	10	8	12	5.7	0.0	0.0
Wilmington	78	81	91	29.95	30.03	.00	60.2	−1.8	81	25	69	38	17	51	26	55	51	76	7.19	+4.5	11	5,881	sw.	29	s.	27	13	7	10	4.7	0.0	0.0
Charleston	48	11	92	29.97	30.02	−.01	64.0	−0.5	83	25	72	43	16	56	25	58	54	75	2.54	0.0	9	8,020	sw.	42	sw.	23	14	8	8	4.7	0.0	0.0
Columbia, S. C.	351	41	57	29.63	30.01	−.02	61.4	−1.9	83	2	72	39	17	51	33	53	47	67	6.39	+3.5	10	5,468	sw.	29	sw.	22	12	7	11	5.5	0.0	0.0
Due West	711	10	55	29.25	30.03		58.0		79	25	68	34	16	48	32				5.96		10	7,128	sw.	36	sw.	7	8	10	12	5.7	0.0	0.0
Greenville, S. C.	1,039	139	146	28.89	29.90		56.6	−2.0	79	2	66	34	16	47	30	50	45	70	5.66		12	6,815	ne.	34	sw.	7	7	9	14	6.4	0.0	0.0
Augusta	182	62	77	29.80	30.00	−.03	62.4	−1.8	85	21	73	40	17	52	33	54	47	63	6.40	+3.3	10	4,712	s.	26	w.	7	12	7	11	5.0	0.0	0.0
Savannah	65	150	194	29.96	30.03	.00	64.6	−1.4	82	20	74	43	28	55	27	58	53	73	4.12	+1.6	8	8,773	s.	38	sw.	23	11	11	8	4.8	0.0	0.0
Jacksonville	43	200	245	29.98	30.03	−.01	66.6	−2.1	85	22	75	47	28	59	22	59	54	69	8.10	+5.8	9	8,180	s.	35	nw.	28	12	11	7	4.5	0.0	0.0
Florida Peninsula							73.4	+0.2										72	2.16	0.0										4.2		
Key West	22	10	64	29.98	30.00	−.02	76.0	+0.3	87	26	81	62	29	71	14	69	66	75	1.74	+0.4	4	8,295	se.	33	w.	11	22	3	5	3.0	0.0	0.0
Miami	25	71	164	30.01	30.04		73.6	+0.8	87	16	79	48	29	68	25	67	63	72	0.42	−2.9	6	8,876	e.	30	s.	11	11	12	7	5.0	0.0	0.0
Tampa	35	79	87	29.99	30.03	−.03	70.5	−0.4	88	22	80	47	1	61	28	62	58	70	4.31	+2.5	6	4,911	e.	27	sw.	27	14	8	8	4.7	0.0	0.0
Titusville	44	5		29.99	30.04		68.6		86	15	78	42	29	59	34				5.37		8		se.				15	6	9	4.1	0.0	0.0
East Gulf States							61.3	−3.4										70	8.26	+3.9										5.1		
Atlanta	1,173	190	216	28.76	30.01	−.02	57.9	−3.1	77	25	67	38	28	49	26	50	43	64	5.42	+1.8	11	8,117	nw.	45	nw.	27	8	8	14	6.0	T.	0.0
Macon	370	78	87	29.61	30.01	−.02	60.6	−3.3	81	25	71	37	1	50	36	53	47	67	8.02	+4.6	11	4,909	s.	25	nw.	27	14	4	12	5.1	0.0	0.0
Thomasville	273	49	58	29.72	30.02	−.01	64.5	−2.2	85	26	75	43	1	54	30	56	51	69	7.92	+4.3	9	3,314	sw.	22	sw.	23	11	8	11	5.5	0.0	0.0
Apalachicola	36	42	49	29.98	30.01		64.4		77	23	71	47	1	58	19	59	56	76	18.62		8	6,099	s.	27	e.	10	15	7	8	4.1	0.0	0.0
Pensacola	56	149	185	29.94	30.00	−.02	63.1	−3.6	75	26	69	42	16	57	23	58	55	78	8.73	+4.7	9	9,995	se.	38	s.	22	12	9	9	4.6	0.0	0.0
Anniston	741	9	57	29.22	30.01	−.02	57.8	−2.6	80	26	69	31	16	46	39				8.17	+4.5	12	4,113	s.	22	nw.	27	14	5	11	5.0	0.0	0.0
Birmingham	700	11	48	29.24	30.00	−.02	59.1	−4.2	81	25	69	33	16	49	30	51	45	66	9.50	+4.8	12	5,932	s.	28	s.	22	11	6	13	5.4	0.0	0.0
Mobile	57	125	161	29.93	30.00	−.02	63.2	−3.1	79	22	72	41	16	55	27	58	54	78	6.86	+2.2	8	8,218	s.	40	nw.	6	12	8	10	4.9	0.0	0.0
Montgomery	223	100	112	29.75	30.00	−.03	61.4	−3.9	82	26	71	39	16	52	31	54	47	66	9.58	+5.3	11	5,172	s.	24	n.	27	10	8	12	5.5	0.0	0.0
Corinth	469	6					58.7		79	5	69	32	16	48	34				5.12		11		s.				0	26	4		0.0	0.0
Meridian	375	87	95	29.59	29.99	−.03	60.6	−3.4	85	20	72	36	16	50	35	53	47	66	9.94	+4.9	9	5,252	sw.	25	nw.	27	15	4	11	4.8	0.0	0.0
Vicksburg	247	65	73	29.72	30.00	.00	60.8	−4.8	84	20	71	38	9	51	30	54	50	71	9.30	+4.1	10	5,856	s.	30	se.	21	12	7	11	4.8	0.0	0.0
New Orleans	53	76	84	29.93	29.99	−.01	65.6	−3.2	85	20	74	46	15	58	24	59	54	72	7.47	+2.2	7	5,227	se.	26	se.	5	13	5	12	5.2	0.0	0.0
West Gulf States							62.2	−4.3										71	3.30	−0.3										5.1		
Shreveport	249	77	93	29.69	29.96	−.01	61.4	−4.4	85	20	71	35	14	52	34	54	48	70	5.81	+1.2	11	5,083	se.	23	nw.	21	13	3	14	5.3	T.	0.0
Bentonville	1,303	11	44	28.54	29.91	−.05	53.2	−3.7	79	1	63	26	15	43	32				9.85		9		s.		s.		19	3	8		0.0	0.0
Fort Smith	457	79	94	29.44	29.92	−.04	57.0	−4.8	81	1	67	32	15	48	34	50	43	63	7.31	+3.4	7	6,333	e.	35	sw.	5	10	7	13	5.9	0.0	0.0
Little Rock	357	136	144	29.57	29.95	−.03	57.6	−4.5	80	18	67	35	15	48	31	50	43	65	7.01	+2.5	12	7,398	s.	33	e.	5	10	5	15	5.9	T.	0.0
Austin	605	136	148	29.28	29.91		64.0	−3.8	92	21	76	36	9	52	39	57	53	74	2.14	−2.2	7	7,983	s.	34	ne.	14	11	10	9	5.0	T.	0.0
Brownsville	57	53	61	29.82	29.88		69.4	−4.3	90	21	78	44	9	61	29	62	58	76	1.70	+0.3	7	7,261	s.	29	n.	8	11	12	7	4.7	0.0	0.0
Corpus Christi	20	11	78	29.89	29.91	−.04	67.2	−3.6	88	5	75	43	10	60	36	61	*58	78	0.50	−1.3	6	10,965	se.	39	n.	14	10	10	10	5.3	0.0	0.0
Dallas	512	220	227	29.38	29.92		60.8		89	30	71	32	15	51	31				3.88		10	10,509	se.	44	nw.	26	12	9	9	4.8	T.	0.0
Fort Worth	670	106	114	29.18	29.89	−.05	62.2	−2.8	95	30	74	33	15	51	35	53	48	67	5.70	+1.6	8	8,280	s.	38	se.	3	9	10	11	5.7	T.	0.0
Galveston	54	106	114	29.91	29.97	.00	63.6	−5.1	80	22	69	41	15	58	26	59	56	80	1.43	−1.6	6	9,045	s.	36	w.	5	14	6	10	4.7	0.0	0.0
Groesbeck	461	11	56	29.44	29.93		61.4		87	30	72	34	15	51	36				2.42		8	10,385	s.	36	se.	5	14	7	9	4.8	T.	0.0
Houston	138	202	314	29.81	29.96		63.4	−6.2	80	30	71	38	15	55	30				1.54	−2.3	7	10,933	se.	50	ne.	9	14	5	11	4.8	0.0	0.0
Palestine	510	64	72	29.41	29.95	−.01	60.8	−5.2	85	30	70	34	15	51	35	54	50	72	2.68	−1.7	9	6,896	s.	31	se.	5	12	5	13	5.2	T.	0.0
Port Arthur	34	58	66	29.92	29.96		63.6		81	22	70	38	15	57	26				4.46		9	7,040	s.	30	ne.	9	12	5	13	5.4	0.0	0.0
San Antonio	693	119	132	29.18	29.90	−.03	65.8	−3.3	93	21	77	37	9	54	39	56	49	63	1.70	−1.5	8	6,251	se.	30	se.	4	13	9	8	4.7	0.0	0.0
Taylor	583	55	63	29.35	29.96	+.01	63.3	−4.2	90	21	75	35	15	52	40				2.14	−1.8	6	8,303	s.	30	se.	5	13	11	6	4.5	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind (3-cup anemometer used): Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							51.2	-3.6										62	4.45	+0.8										6.4		
Chattanooga	762	189	213	29.18	29.99	-.04	56.8	-3.5	78	2	66	34	9	47	31	48	40	60	7.79	+2.9	13	7,114	sw.	34	se.	21	3	13	14	6.4	T.	0.0
Knoxville	995	102	111	28.93	29.99	-.04	55.6	-2.4	79	4	66	32	16	46	30	47	40	62	5.54	+1.4	15	6,273	sw.	30	sw.	7	2	16	12	6.6	T.	0.0
Memphis	399	76	97	29.54	29.96	-.04	57.4	-4.4	77	18	66	35	15	49	26	49	42	61	6.70	+1.9	13	6,464	sw.	32	w.	13	10	7	13	5.9	0.0	0.0
Nashville	546	168	191	29.41	30.00	-.01	55.6	-3.4	77	3	65	33	15	46	32	47	39	56	3.22	-0.9	12	8,266	s.	46	se.	6	7	10	13	6.2	0.0	0.0
Lexington	989	193	230	28.91	29.98	-.04	50.6	-3.7	77	2	60	28	15	42	33				2.79	-0.6	12	10,147	sw.	46	nw.	14	7	13	10	5.8	T.	0.0
Louisville	525	188	234	29.40	29.98	-.03	52.3	-4.1	79	2	61	29	10	43	33	45	40	68	4.15	+0.3	9	8,795	s.	41	s.	6	7	9	14	6.3	T.	0.0
Evansville	431	76	116	29.51	29.99	-.01	52.5	-4.2	76	5	61	31	9	44	30	45	37	61	5.23	+1.3	12	7,658	s.	37	s.	5	5	16	9	6.1	T.	0.0
Indianapolis	822	194	230	29.06	29.96	-.04	47.8	-4.3	76	2	57	24	15	39	33	41	32	59	2.76	-0.9	14	9,526	w.	38	w.	14	10	10	10	5.5	T.	0.0
Royal Center	736	11	55	29.13	29.94		45.2		75	3	56	21	15	34	33				1.42		13	9,185	w.	39	w.	30	5	16	9	6.3	0.3	0.0
Terre Haute	575	96	129	29.33	29.95		49.4		78	2	59	26	9	40	32	42	35	64	2.09		11	7,954	s.	33	se.	6	4	13	13	6.3	0.2	0.0
Cincinnati	627	11	51	29.29	29.97	-.04	49.6	-2.8	78	2	59	27	10	40	38	42	35	62	3.66	+0.5	13	6,986	sw.	34	sw.	14	4	14	12	6.5	T.	0.0
Columbus	822	179	222	29.08	29.97	-.05	47.4	-3.8	78	6	57	27	15	38	39	41	34	63	2.92	0.0	9	8,508	s.	41	w.	30	1	23	6	6.0	0.1	0.0
Dayton	899	137	173	28.99	29.96		48.2	-3.4	75	6	58	26	10	39	35	41	34	62	3.62	+0.4	12	8,180	sw.	42	s.	6	3	18	9	6.8	0.1	0.0
Elkins	1,947	59	67	27.91	29.99	-.04	45.8	-3.0	78	5	56	18	16	36	37	39	32	65	6.74	+3.4	12	5,366	w.	29	w.	19	4	12	14	7.0	17.0	T.
Parkersburg	637	77	82	29.33	29.99	-.04	50.1	-3.3	82	6	60	27	16	40	35	42	34	60	3.15	+0.2	11	5,093	sw.	29	sw.	14	7	9	14	6.9	T.	0.0
Pittsburgh	842	353	410	29.05	29.96	-.06	40.6	-4.6	80	6	55	25	16	38	36	40	33	63	4.05	+1.1	14	8,624	w.	45	w.	19	1	10	19	7.7	4.3	0.0
Lower Lake Region							43.0	-2.4										69	2.43	+0.1										6.2		
Buffalo	767	247	280	29.08	29.92	-.09	39.6	-3.2	78	6	47	20	16	32	37	36	33	81	2.10	-0.5	16	12,421	sw.	70	sw.	14	6	12	12	6.3	3.3	0.0
Canton	448	10	61	29.40	29.89		39.4	-3.1	78	6	48	19	2	30	36				2.80	+0.5	14	8,157	w.	41	sw.	15	10	8	12	6.2	3.9	0.0
Ithaca	836	5	100	29.04	29.96		42.2		81	5	52	20	10	33	36	36	31	68	3.64	+1.1	15	7,968	nw.	46	se.	14	6	9	15	6.6	4.1	0.0
Oswego	335	76	91		29.92	-.09	41.1	-2.5	78	7	49	25	9	34	29			73	2.95	+0.6	15		nw.	30	w.	19	9	7	14		1.1	0.0
Rochester	523	86	102	29.36	29.94	-.07	43.2	-1.7	83	6	52	23	16	34	33	37	31	66	2.60	+0.2	14	6,901	w.	44	sw.	19	7	9	14	6.4	3.0	0.0
Syracuse	597	97	113	29.28	29.93	-.08	42.4	-2.0	80	6	50	24	16	35	30				3.26	+1.0	16	9,313	nw.	44	nw.	19	4	11	15	6.6	9.7	0.0
Erie	714	130	166	29.16	29.94	-.08	43.7	-1.4	79	6	52	25	15	36	31	38	33	66	2.57	-0.2	13	10,680	sw.	47	sw.	14	9	11	10	5.4	2.3	0.0
Cleveland	762	190	201	29.11	29.95	-.07	44.2	-2.0	77	6	52	26	15	37	35	39	33	66	2.15	-0.3	14	9,654	w.	46	w.	30	6	15	9	6.1	1.0	0.0
Sandusky	629	5	67	29.26	29.95	-.07	45.6	-1.6	78	6	54	25	10	37	36				2.34	-0.2	14	7,518	sw.	38	sw.	14	1	15	14	7.0	0.4	0.0
Toledo	628	208	243	29.25	29.94	-.07	44.7	-2.9	75	6	53	25	15	36	34	39	33	66	2.39	-0.3	12	10,578	w.	56	sw.	14	10	12	8	5.5	0.6	0.0
Fort Wayne	856	113	124	29.00	29.93		45.6	-3.7	74	3	55	25	9	36	33	39	33	67	2.00		11	7,587	w.	32	sw.	14	6	14	10	6.2	0.5	0.0
Detroit	730	218	258	29.13	29.93	-.09	43.7	-2.5	73	3	52	24	9	35	29	38	33	72	1.96	-0.5	10	8,058	sw.	48	sw.	14	6	11	13	6.3	0.4	0.0
Upper Lake Region							38.1	-3.5										73	2.81	+0.4										5.8		
Alpena	609	13	92	29.22	29.90	-.12	36.2	-2.4	69	4	44	16	15	28	33	33	28	75	3.69	+1.4	13	8,032	nw.	35	ne.	14	11	11	8	5.3	4.8	0.0
Escanaba	612	54	60	29.23	29.91	-.11	33.3	-4.6	60	28	40	11	9	27	29	30	26	76	2.36	+0.1	14	7,768	s.	44	n.	14	11	8	11	5.3	13.3	0.0
Grand Haven	632	54	89	29.21	29.90	-.11	40.2	-3.5	67	3	48	22	8	33	31	36	32	74	2.75	+0.1	13	8,568	w.	49	w.	19	8	13	9	5.7	1.7	0.0
Grand Rapids	707	70	87	29.14	29.92	-.10	43.2	-3.8	73	4	52	22	15	35	30	37	31	66	2.66	-0.1	15	4,871	nw.	26	nw.	19	5	11	14	6.4	0.8	0.0
Houghton	668	64	99	29.17	29.91	-.11	33.8	-3.9	72	4	42	12	8	26	38				3.88	+1.8	13	7,207	w.	35	n.	8	6	11	13	6.5	25.7	0.0
Lansing	878	6	49	28.96	29.91		42.0	-3.6	74	4	52	20	10	32	36	38	33	75	1.81	-0.8	13	5,080	w.	25	nw.	14	8	14	8	5.4	0.7	0.0
Ludington	637	60	66	29.19	29.90		38.3		64	29	45	20	8	31	27	35	31	77	2.97		13	7,435	n.	31	s.	3	12	9	9	5.4	6.4	0.0
Marquette	734	77	111	29.10	29.91	-.11	34.8	-3.0	67	4	42	15	9	28	31	31	26	72	4.68	+2.2	15	7,814	nw.	35	s.	2	7	7	16	6.7	37.1	0.0
Port Huron	638	70	120	29.21	29.92	-.10	42.0	-1.0	74	3	50	23	10	34	32	37	32	72	1.52	-0.7	11	8,783	sw.	43	w.	10	9	13	8	5.6	0.5	0.0
Sault Ste. Marie	614	11	52	29.20	29.91	-.12	32.5	-4.9	69	29	40	10	20	24	37	29	26	80	3.80	+1.7	16	6,250	nw.	35	nw.	13	9	12	9	5.4	13.8	0.0
Chicago	673	7	131	29.18	29.92	-.08	44.7	-2.2	75	3	52	23	9	37	30	38	33	67	2.34	-0.4	9	8,415	ne.	32	w.	30	8	11	11	5.7	1.0	0.0
Green Bay	617	109	141	29.22	29.90	-.11	37.6	-5.6	67	4	46	12	9	29	31	34	29	72	2.29	-0.2	16	8,420	s.	40	n.	14	7	9	14	6.4	11.0	0.0
Milwaukee	681	125	221	29.16	29.91	-.08	41.1	-2.7	68	4	49	20	15	34	27	36	31	72	1.79	-0.9	10	9,505	nw.	39	sw.	4	10	9	11	5.6	6.0	0.0
Duluth	1,133	5	47	28.68	29.92	-.09	33.3	-3.7	67	28	42	10	8	25	32	29	23	71	2.90	+0.8	13	8,665	nw.	40	nw.	12	8	8	16	6.0	11.3	0.0
North Dakota							36.0	-4.8										63	1.03	-0.7										5.3		
Moorhead	940	50	58	28.90	29.94	-.05	36.6	-4.0	77	2	48	9	8	26	37	31	23	64	1.37	-0.8	7	6,965	n.	31	nw.	2	6	12	12	6.0	6.9	0.0
Bismarck	1,674	8	57	28.14	29.96	-.01	37.0	-5.1	77	28	49	4	19	25	39	31	23	61	1.15	-0.4	5	6,725	n.	40	nw.	29	9	14	7	4.9	4.5	0.0
Devils Lake	1,478	11	44	28.35	29.96	-.03	33.8	-4.4	76	28	45	3	19	22	40	29	22	67	1.08	-1.0	6	7,213	n.	34	n.	2	14	7	9	4.7	8.9	0.0
Ellendale	1,457	10	56	28.36	29.94		37.0		75	28	50	7	8	24	46				1.08		9	10,287	nw.	49	nw.	29	7	10	13	6.2	2.7	0.0
Grand Forks	833	12	67				36.1		76	28	47	7	19	25	39	31			0.59		2		nw.		nw.		12	12	6		5.0	0.0
Williston	1,878	41	48	27.94	29.96	.00	36.4	-5.6	76	27	47	6	19	26	37	30	21	59	0.53	-0.7	9	5,859	n.	32	nw.	29	10	12	8	5.1	5.0	0.0
Upper Mississippi Valley							45.8	-4.4										66	2.86	-0.1										5.8		
Minneapolis	918	102	208	28.90	29.90		39.6	-6.8	74	4	48	18	14	31	31				2.33	+0.1	8	9,175	nw.	42	n.	6	7	7	16	6.8	16.9	0.0
St. Paul	837	236	261	29.00	29.92	-.07	39.0	-6.6	73	4	48	16	15	30	31				2.45	+0.1	8	9,714	nw.	41	sw.	30	7	6	17	6.8	20.3	0.0
La Crosse	714	11	48	29.13	29.91	-.07	42.4	-4.8	73	2	52	17	9	33	37	37	31	70	2.41	0.0	10	4,434	nw.	22	nw.	30	8	10	12	6.0	9.7	0.0
Madison	974	70	78	28.85	29.92	-.07	41.4	-4.0	69	2	50	18	9	33	30	36	31	70	*2.57	-0.2	11	6,953	nw.	30	nw.	30	7	13	10	6.0	7.4	0.0
Wausau	1,247	4		28.55	29.91		37.1		68	4	47	5	15	28	37				3.11		14		nw.				10	5	15	6.0	19.2	0.0
Charles City	1,015	10	49	28.83	29.93	-.05	41.1	-5.3	74	2	51	15	15	31	37	36	30	68	2.81	0.0	10	6,116	nw.	26	s.	4	11	10	9	5.1	6.0	0.0
Davenport	606	71	79	29.26	29.92	-.06	46.8	-3.1	78	2	56	22	15	38	30	40	34	66	3.86	+1.2	10	6,117	nw.	28	w.	30	9	9	12	5.9	1.5	0.0
Des Moines	861	84	97	29.00	29.92	-.05	45.4	-5.7	80	2	56	19	9	35	35	39	31	62	1.95	-1.0	9	6,154	n.	28	sw.	2	7	7	16	6.4	3.1	0.0
Dubuque	700	81	96	29.16	29.92	-.06	44.2	-4.4	75	2	53	21	9	35	30	38	32	66	1.71	-1.1	12	5,645	nw.	26	nw.	30	8	12	10	5.9	3.5	0.0
Keokuk	614	64	78	29.26	29.94	-.04	48.7	-3.6	82	2	58	23	9	39	34	41	34	61	2.79	-0.2	11	6,276	n.	34	w.	14	10	5	15	5.8	2.3	0.0
Cairo	358	87	93	29.58	29.97	-.02	54.0	-4.1	77	2	63	32	15	45	30	46	40	64	5.76	+2.0	13	7,867	s.	33	sw.	29	8	7	15	6.3	0.0	0.0
Peoria	609	11	45	29.28	29.95	-.04	47.6	-3.3	80	3	58	23	9	37	36	41	35	67	2.84	-0.5	9	6,088	w.	27	w.	14	12	10	8	4.6	0.1	0.0
Springfield, Ill.	636	10	91	29.25	29.93	-.05	49.3	-3.4	79	3	59	25	15	40	35	43	37	66	2.88	-0.6	8	6,890	s.	29	w.	14	9	9	12	5.2	T.	0.0
Hannibal	534	74	109	29.36	29.93	-.05	50.0	-3.4	82	2	60	25	9	40	38				2.61	-0.6	9	7,087	w.	34	s.	4	12	7	11	5.3	0.4	0.0
St. Louis	568	265	303	29.33	29.94	-.04	52.4	-3.4	81	29	61	27	15	44	32	46	41	70	3.02	-0.8	8	9,372	sw.	47	sw.	6	11	8	11	5.5	T.	0.0
Missouri Valley							47.3	-3.8										57	2.06	-0.8										5.0		
Columbia, Mo.	784	6	84	29.09	29.93	-.05	51.2	-3.7	82	1	61	23	9	41	36				2.89	-0.8	7	6,704	nw.	31	nw.	14	11	9	10	5.3	T.	0.0
Kansas City	963	161	181	28.88	29.92	-.04	51.4	-3.4	84	1	61	25	15	42	33	43	35	58	2.32	-0.8	6	8,325	s.	42	nw.	13	13	9	8	4.8	T.	0.0
St. Joseph	967	11	49	28.87	29.92		50.6		85	2	61	23	9	40	39	41	31	55	2.06		7	7,424	nw.	38	nw.	13	16	7	7	4.4	T.	0.0
Springfield, Mo.	1,324	98	104	28.52	29.93	-.04	51.8	-4.2	80	1	61	25	15	43	31	44	36	61	6.62	+2.8	9	7,886	s.	36	s.	13	19	2	9	4.0	T.	0.0
Iola	984	11	50	28.86	29.91	-.04	52.6	-3.6	82	29	64	25	9	42	35				4.24	+0.2	9	5,758	s.	25	nw.	13	15	6	9	4.9	T.	0.0
Topeka	987	92	107				51.6	-3.1	88	2	62	25	15	41	37				2.69	0.0	6	8,469	sw.	46	n.	13	15	9	6	4.4	T.	0.0
Lincoln	1,189	11	81	28.64	29.92	-.02	48.2	-3.3	88	3	60	20	9	36	46	39	28	53	1.18	-1.6	5	8,297	s.	36	nw.	29	8	14	8	5.6	7.0	0.0
Omaha	1,105	115	122	28.74	29.93	-.02	47.4	-3.8	88	3	58	19	9	37	38	38	28	54	1.51	-1.0	5	6,785	nw.	42	n.	13	10	8	12	5.4	8.9	0.0
Valentine	2,598	47	54	27.20	29.94	.00	42.8	-2.9	82	28	56	12	8	29	44	34	25	56	0.55	-1.8	7	7,275	nw.	34	nw.	29	7	17	6	4.8	5.1	0.0
Sioux City	1,135	94	164	28.72	29.95	.00	44.2	-3.6	83	2	56	15	8	32	40	37	28	60	0.22	-2.6	5	9,710	nw.	48	nw.	18	9	8	13	5.6	1.5	0.0
Huron	1,306	59	74	28.53	29.95	-.01	40.0	-5.1	80	2	53	6	14	27	42	33	24	60	1.27	-1.0	7	7,464	nw.	36	w.	20	6	18	6	5.1	4.7	0.0
Pierre	1,572	70	75		29.95	.00	43.3	-3.5	81	1	55	12	8	31	46			58	0.99	-1.0	6	7,604	nw.	36	nw.	20	9	14	7		2.6	0.0
Yankton	1,233	49	57	28.60	29.94	-.01	43.0	-4.9	82	2	56	13	14	30	39				0.22	-2.6	5	6,469	nw.	29	nw.	20	9	9	12	5.8	0.7	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with .01, or more	Wind (3-cup anemometer used): Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							40.5	-2.7										59	0.85	-0.8										6.0		
Billings	3,140	5					44.3		86	27	50	11	8	29	53				0.48		10		sw.				10	7	13			
Havre	2,505	11	44	27.25	29.91	-.02	41.0	-2.7	84	27	53	9	8	29	40	34	26	62	0.64	-0.4	10	5,419	sw.	31	sw.	27	5	14	11	6.4	2.7	0.0
Helena	4,110	87	112	25.69	29.92	-.05	41.6	-1.9	77	26	52	11	8	31	37	34	26	58	0.55	-0.6	8	5,595	sw.	30	w.	27	3	7	20	7.5	6.0	0.0
Kalispell	2,973	48	56	26.84	29.92	-.04	40.5	-3.1	68	24	49	20	7	32	31	35	28	65	1.80	+0.7	13	4,159	nw.	29	w.	9	4	17	9	6.4	4.7	0.0
Miles City	2,371	48	55	27.39	29.97	+.01	43.0	-1.7	81	27	54	10	8	32	39	35	26	59	0.43	-0.8	9	3,057	s.	31	w.	29	8	14	8	5.3	0.9	0.0
Rapid City	3,259	50	58	26.50	29.96	+.01	40.6	-3.7	76	28	52	9	8	29	40	34	24	53	0.92	-1.4	8	5,918	n.	32	n.	28	9	15	6	5.1	9.1	0.0
Cheyenne	6,088	84	101	23.88	29.90	-.01	38.4	-2.5	70	30	50	5	8	26	36	30	20	53	0.83	-1.2	7	9,622	w.	42	w.	29	4	17	9	6.0	6.4	0.0
Lander	5,372	60	68	24.53	29.92	-.02	39.8	-2.6	72	27	52	9	8	27	41	33	27	65	0.80	-1.6	5	5,139	w.	36	sw.	19	7	21	2	5.1	9.5	0.0
Sheridan	3,790	10	47	25.99	29.92		42.2		80	27	55	13	8	29	45	34	26	62	1.70		11	4,358	nw.	34	nw.	28	9	17	4	5.5	10.2	0.0
Yellowstone Park	6,241	11	48	23.76	29.95	-.01	33.3	-3.7	66	27	44	-2	8	23	37	28	21	63	1.51	+0.1	15	5,554	sw.	30	sw.	2	2	12	16	7.2	19.2	0.0
North Platte	2,821	11	51	26.97	29.91	-.01	46.6	-2.0	85	28	61	14	8	32	48	36	25	51	0.04	-2.0	2	5,903	n.	31	n.	13	8	11	11	5.6	T.	0.0
Middle Slope							50.6	-2.8										53	2.40	+0.2										5.2		
Denver	5,292	106	113	24.61	29.88	-.02	45.8	-1.3	76	28	58	12	8	33	36	35	20	45	1.36	-0.7	5	5,518	s.	31	e.	18	10	13	7	4.9	13.4	0.0
Pueblo	4,685	80	86	25.17	29.85	-.03	47.7	-2.4	80	30	62	15	9	33	50	36	22	45	0.29	-1.1	2	5,310	e.	28	nw.	6	10	15	5	4.9	T.	0.0
Concordia	1,392	50	58	28.45	29.94	+.01	50.8	-2.7	89	3	62	22	14	39	36	41	30	55	1.25	-1.1	5	7,121	s.	29	s.	3	7	17	6	5.3	4.5	0.0
Dodge City	2,509	11	51	27.31	29.91	+.01	50.2	-3.4	87	3	63	20	14	37	48	40	29	54	2.54	+0.6	7	7,610	ne.	37	ne.	5	19	6	5	3.6	2.5	0.0
Wichita	1,358	139	158	28.46	29.89	-.04	52.8	-3.6	85	2	63	25	14	43	38	44	35	58	5.26	+2.6	9	9,868	s.	39	se.	4	12	11	7	4.9	T.	0.0
Broken Arrow	765	11	56	29.09	29.92		55.5		84	18	66	27	15	45	36				6.55		8	10,303	s.	45	nw.	13	5	8	17	6.6	T.	0.0
Oklahoma City	1,214	10	47	28.61	29.89	-.03	56.2	-3.6	85	3	66	30	15	46	37	47	39	59	3.68	+0.9	7	7,904	s.	30	n.	13	8	9	13	6.3	T.	0.0
Southern Slope							60.8	-2.0										46	0.73	-1.1										4.4		
Abilene	1,738	10	52	28.07	29.86	-.04	63.2	-1.2	90	29	77	30	15	50	39	50	38	49	0.93	-1.8	4	8,993	s.	34	w.	5	9	12	9	5.5	T.	0.0
Amarillo	3,676	10	49	26.15	29.86	-.01	54.4	-1.4	90	17	69	25	9	40	46	41	28	48	0.77	-1.0	6	6,810	sw.	25	sw.	16	13	10	7	4.1	2.7	0.0
Del Rio	944	64	71	28.88	29.85	-.04	68.6	-2.0	96	30	81	37	15	56	44	55	43	50	0.51	-1.4	2	7,282	se.	34	w.	5	20	6	4	3.1	0.0	0.0
Roswell	3,566	75	85	26.25	29.83	-.02	57.2	-3.4	93	30	73	26	10	42	46	42	22	36	0.72	-0.2	4	6,662	s.	38	w.	4	11	12	7	4.8	2.9	0.0
Southern Plateau							57.6	+0.2										35	0.46	0.0										2.9		
El Paso	3,778	152	175	26.00	29.83	.00	62.0	-1.4	95	30	75	29	10	49	42	43	20	26	0.22	0.0	2	9,138	w.	48	w.	4	21	8	1	2.3	0.3	0.0
Santa Fe	7,013	38	53	23.14	29.82	-.02	45.0	-1.7	78	30	57	17	9	33	35	33	19	44	1.63	+0.6	7	4,121	sw.	24	nw.	6	9	13	8	5.5	12.2	0.0
Flagstaff	6,907	10	59	23.27	29.83	-.01	42.6	+0.4	76	30	58	13	5	27	41	32		50	0.35		3		nw.		sw.		14	15	1		T.	0.0
Phoenix	1,108	10	82	28.68	29.82	-.05	67.8	+0.8	98	27	83	38	5	52	41	48	26	25	T.	-0.4	0	3,107	w.	27	n.	8	16	10	4	3.4	0.0	0.0
Yuma	141	9	54	29.71	29.86	-.03	70.4	+0.9	98	28	87	45	9	54	44	52	31	31	0.00	-0.1	0	4,061	w.	31	n.	8	25	5	0	1.6	0.0	0.0
Independence	3,957	5	25	25.88	29.89	-.01	57.5	+2.4	88	29	73	30	9	42	43	42			0.06		1		nw.				17	11	2	1.8	0.0	0.0
Middle Plateau							47.0	-1.4										41	0.59	-0.4										4.3		
Reno	4,532	74	81	25.44	29.97	.00	47.1	-0.2	78	29	60	20	4	34	40	38	28	52	0.66	+0.2	5	5,766	w.	39	sw.	16	12	12	6	4.3	6.6	0.0
Tonopah	6,090	12	20				47.0		81	30	58	20	4	36	30	34	13	24	T.		0		nw.									
Winnemucca	4,344	18	56	25.50	30.00	+.04	44.9	-1.8	78	30	59	17	21	30	43	37	28	57	0.54	-0.3	4	5,368	sw.	33	sw.	2	14	16	0	3.9	0.3	0.0
Modena	5,473	10	43	24.53	29.86	-.02	45.1	-0.9	79	30	61	13	9	29	49	34	16	37	T.	-0.8	0	8,453	w.	41	sw.	2	17	10	3	3.2	T.	0.0
Salt Lake City	4,360	163	203	25.55	29.92	.00	47.9	-1.7	82	30	58	25	8	38	34	37	24	43	1.55	-0.5	6	5,383	nw.	30	se.	24	9	14	7	5.3	6.5	0.0
Grand Junction	4,602	60	68	25.26	29.83	-.05	50.1	-2.3	83	30	63	19	8	37	37	36	18	34	0.19	-0.6	4	4,912	nw.	32	sw.	3	9	15	6	4.6	0.3	0.0
Northern Plateau							47.0	-2.4										56	0.96	-0.4										6.6		
Baker	3,471	48	53	26.40	30.01	+.01	41.9	-3.3	71	26	53	21	7	31	34	35	27	60	0.86	-0.1	14	4,328	se.	30	sw.	17	5	7	18	7.2	2.5	0.0
Boise	2,739	78	86	27.14	30.01	+.03	47.9	-2.5	80	26	58	26	7	38	32	40	30	55	0.79	-0.4	13	4,015	se.	24	w.	16	7	10	13	6.1	T.	0.0
Lewiston	757	40	48	29.18	29.99	+.03	50.8	-2.1	84	26	61	28	7	40	40				0.98	-0.2	14	3,142	e.	28	nw.	28	3	14	13	7.0	0.0	0.0
Pocatello	4,477	60	68	25.39	29.92	-.02	44.1	-1.9	76	27	55	17	8	34	33	35	23	47	0.74	-1.3	8	6,558	sw.	28	sw.	17	5	17	8	6.0	2.0	0.0
Spokane	1,929	101	110	27.91	29.97	-.02	46.2	-2.2	78	26	56	29	8	37	37	39	30	60	0.93	-0.2	11	4,887	s.	28	sw.	28	3	11	16	6.9	T.	0.0
Walla Walla	991	57	65	28.91	29.99	-.02	51.0	-2.1	75	26	60	31	7	42	30	43	34	56	1.35	-0.2	14	3,964	s.	25	w.	16	5	12	13	6.4	T.	0.0
North Pacific Coast Region							49.1	0.0										72	4.00	+0.8										7.3		
North Head	211	11	56	29.74	29.97	-.08	48.1	+0.6	71	8	53	37	1	43	23	44	41	80	5.88	+2.9	25	11,150	s.	54	s.	16	2	4	24	8.7	0.0	0.0
Port Angeles	29	8	53		29.99		46.6		66	26	54	31	1	39	27				1.14	-1.8	17	4,247	sw.	29	w.	26	5	8	17		0.0	0.0
Seattle	125	215	250	29.86	29.99	-.04	48.8	-0.6	71	8	55	36	2	42	25	44	39	74	2.60	+0.2	18	6,372	s.	44	sw.	16	2	7	21	7.8	0.0	0.0
Tacoma	194	172	201	29.79	30.00	-.03	48.6	-0.1	71	26	56	34	2	42	29				3.28	+0.4	19	6,049	s.	44	s.	16	3	13	14	6.8	0.0	0.0
Tatoosh Island	86	9	53	29.86	29.96	-.04	47.0	+0.9	61	22	51	37	1	43	14	45	42	86	7.07	+0.8	24	10,540	e.	50	sw.	16	4	5	21	7.7	T.	0.0
Yakima	1,071	5					48.7		76	26	62	22	8	35	41	41		61	1.21		9		nw.				6	17	7	5.4	0.0	0.0
Medford	1,425	4	80	28.52	30.03		50.0		77	22	62	30	4	38	41	43	37	67	0.99		14		nw.	25	s.	2	3	10	17	7.0	T.	0.0
Portland, Oreg.	153	68	106	29.87	30.03	-.03	51.4	-0.4	74	22	59	37	6	44	31	45	39	60	4.47	+1.6	23	4,649	sw.	23	e.	7	3	4	23	7.8	T.	0.0
Roseburg	510	75	99	29.50	30.06	-.01	50.7	-0.3	80	8	60	33	6	41	43	45	40	71	3.57	+1.3	23	3,153	nw.	27	sw.	16	3	9	18	7.4	0.0	0.0
Middle Pacific Coast Region							56.3	+0.5										72	2.03	+0.2										4.1		
Eureka	62	73	89	30.04	30.11	.00	50.8	+0.9	72	7	58	36	4	44	28	48	46	85	5.86	+2.5	17	4,813	se.	31	sw.	2	6	9	15	6.4	0.0	0.0
Red Bluff	332	50	56	29.66	30.01	-.02	58.6	-0.4	88	29	70	35	4	47	34	51	44	62	1.24	-0.5	6	3,989	nw.	25	se.	2	16	13	1	3.2	0.0	0.0
Sacramento	69	106	117	29.95	30.02	+.01	57.8	-0.3	85	29	69	38	4	47	31	51	45	68	0.78	-0.7	5	5,425	se.	28	s.	2	18	7	5	3.4	0.0	0.0
San Francisco	155	208	243	29.89	30.06	+.01	57.8	+2.8	80	7	65	45	3	51	25	51	46	71	1.31	-0.3	6	6,011	w.	32	w.	19	14	12	4	3.7	0.0	0.0
San Jose	141	12	110	29.92	30.07		56.3	-0.4	83	29	69	36	4	44	37				0.96	-0.1	4	4,340	nw.	23	nw.	3	17	7	6	3.7	0.0	0.0
South Pacific Coast Region							61.1	+1.7										64	0.24	-0.7										3.1		
Fresno	327	89	98	29.66	30.02	+.03	61.4	+1.2	90	29	74	39	4	48	37	51	42	57	0.29	-0.7	2	5,653	nw.	27	nw.	23	20	8	2	2.6	0.0	0.0
Los Angeles	338	159	191	29.61	29.98	-.01	62.2	+2.8	83	29	72	48	1	52	29	52	44	59	0.29	-0.8	1	3,942	sw.	21	nw.	4	14	14	2	3.4	0.0	0.0
San Diego	87	62	70	29.88	29.97	-.02	59.6	+1.1	74	9	67	47	5	52	21	54	50	76	0.14	-0.6	2	4,089	w.	18	w.	3	18	10	2	3.4	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.92	30.01		75.8	-0.8	87	28	81	67	17	71	19				0.83	-3.0	12	9,597	e.	30	e.	22	13	16	1	4.2	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[1] 29.73	[1] 29.81	-.02	81.9	+0.3	92	9	89	72	2	74	20				3.38	+0.6	11		nw.		n.		4	20	6	5.7	0.0	0.0
Colon	38	7	97	[1] 29.83	[1] 29.84	-.02	83.4	+2.3	91	25	89	74	7	78	15				0.86	-3.4	11		n.		n.		1	20	9	6.4	0.0	0.0
Alaska																																
Juneau	80	11	54	[2] 29.75	[2] 29.84		39.0		54	25	44	24	3	34	20	35	27	65	4.66		16	5,102	se.	32	se.	26	5	4	21	7.4	2.7	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[2] 30.00	[2] 30.04		74.2		80	24	79	67	6	70	12	68	64	72	3.40	+1.3	15	5,176	e.	26	e.	30	3	17	10	6.1	0.0	0.0

[1] Observations taken bihourly.

[2] Pressure not corrected to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, April, 1928*

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				32.8		38.7	27.0	45	16	3.95		3.0
Sydney, C. B. I.	48	29.87	29.92	+.03	38.4	+3.4	47.8	29.1	68	15	3.68	−0.17	3.0
Halifax, N. S.	88	29.83	29.94	−.02	40.8	+3.0	49.5	32.2	68	24	4.42	+0.24	1.8
Yarmouth, N. S.	65	29.79	29.86	−.10	39.9	+1.0	45.4	34.5	60	20	6.02	+2.20	5.1
Charlottetown, P. E. I.	38	29.78	29.82	−.08	38.7	+3.5	46.2	31.1	61	19	1.90	−0.75	1.7
Chatham, N. B.	28	29.75	29.78	−.12	36.8	+1.3	46.6	27.1	59	5	3.21	+0.58	6.8
Father Point, Que.	20	29.80	29.82	−.11	33.7	+0.5	40.5	27.0	53	16	2.46	+0.88	17.4
Quebec, Que.	296	29.55	29.88	−.11	33.5	−1.6	39.5	27.6	55	14	2.33	+0.24	12.6
Doucet, Que.	1,236												
Montreal, Que.	187												
Ottawa, Ont.	236	29.62	29.89	−.13	36.7	−3.3	45.2	28.1	75	14	2.59	+1.09	6.4
Kingston, Ont.	285	29.60	29.92	−.10	39.0	−1.0	46.3	31.7	73	19	3.45	+1.66	T.
Toronto, Ont.	379	29.49	29.91	−.11	41.7	+0.9	49.9	33.4	72	23	2.58	+0.21	6.8
Cochrane, Ont.	930												
White River, Ont.	1,244	28.53	29.87	−.17	27.3	−5.7	39.8	14.8	68	−6	1.65	+0.40	8.4
London, Ont.	808				41.8		51.5	32.2	73	19	2.68		4.0
Southampton, Ont.	656	29.17	29.90	−.13	36.8	−1.9	45.0	28.7	72	15	3.00	+1.20	4.8
Parry Sound, Ont.	688	29.17	29.87	−.15	36.4	−1.2	45.9	26.9	68	10	3.69	+1.78	2.8
Port Arthur, Ont.	644	29.19	29.92	−.11	31.8	−1.7	40.7	23.0	61	4	1.69	−0.03	11.2
Winnipeg, Man.	760												
Minnedosa, Man.	1,690												
Le Pas, Man.	860				26.8		39.5	14.1	73	−3	0.30		3.0
Qu'Appelle, Sask.	2,115	27.67	29.97	−.02	30.8	−6.6	39.8	21.9	70	2	1.73	+0.68	13.0
Moose Jaw, Sask.	1,759				33.4		43.3	23.5	80	2	0.78		7.2
Swift Current, Sask.	2,392	27.34	29.89	−.07	37.3	−4.0	49.6	25.1	82	4	0.62	−0.31	4.2
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.40	30.01	+.03	31.2	−4.9	42.6	19.8	78	−2	0.45	−0.38	4.5
Battleford, Sask.	1,592	28.20	29.98	+.01	32.3	−4.9	42.4	22.2	77	3	0.66	+0.19	3.7
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.72	29.97	−.04	48.5	+1.7	54.8	42.3	64	35	1.36	−1.01	
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	30.00	30.16	+.11	65.2	+1.3	71.8	58.6	77	51	10.82	+6.64	0.0

LATE REPORTS FOR MARCH, 1928

Father Point, Que.	20	29.70	29.72	−.18	23.4	+3.1	29.4	17.4	43	4	1.52	−1.21	10.0
Doucet, Que.	1,236				12.5		27.0	−2.0	40	−42	1.22		8.8
Kingston, Ont.	285	29.54	29.86	−.15	28.1	+2.5	34.6	21.7	58	2	1.79	−0.85	5.5
White River, Ont.	1,244	28.51	29.87	−.16	12.2	0.0	27.0	−2.5	50	−40	1.12	−0.26	10.2
Parry Sound, Ont.	688	29.15	29.88	−.14	22.4	+1.3	30.4	14.5	47	−10	2.37	+0.14	17.4
Winnipeg, Man.	760	29.18	30.05	−.04	21.4	+9.1	30.5	12.4	62	−14	1.54	+0.51	15.4
Calgary, Alb.	3,428	26.30	29.95	.00	31.2	+5.0	43.1	19.4	68	2	1.27	+0.55	12.7
Kamloops, B. C.	1,262	28.62	29.93	+.01	40.9	+4.8	50.0	31.8	64	14	0.26	−0.31	T.
Barkerville, B. C.	4,180	25.46	29.81	−.07	29.7	+3.6	38.2	21.2	51	4	3.61	+1.72	34.7
Estevan Point, B. C.	20				44.0		49.8	38.2	57	29	10.06		0.0
Prince Rupert, B. C.	170				41.5		48.6	34.4	63	26	8.94		1.4

Chart I. Departure (°F.) of the Mean Temperature from the Normal, April, 1928

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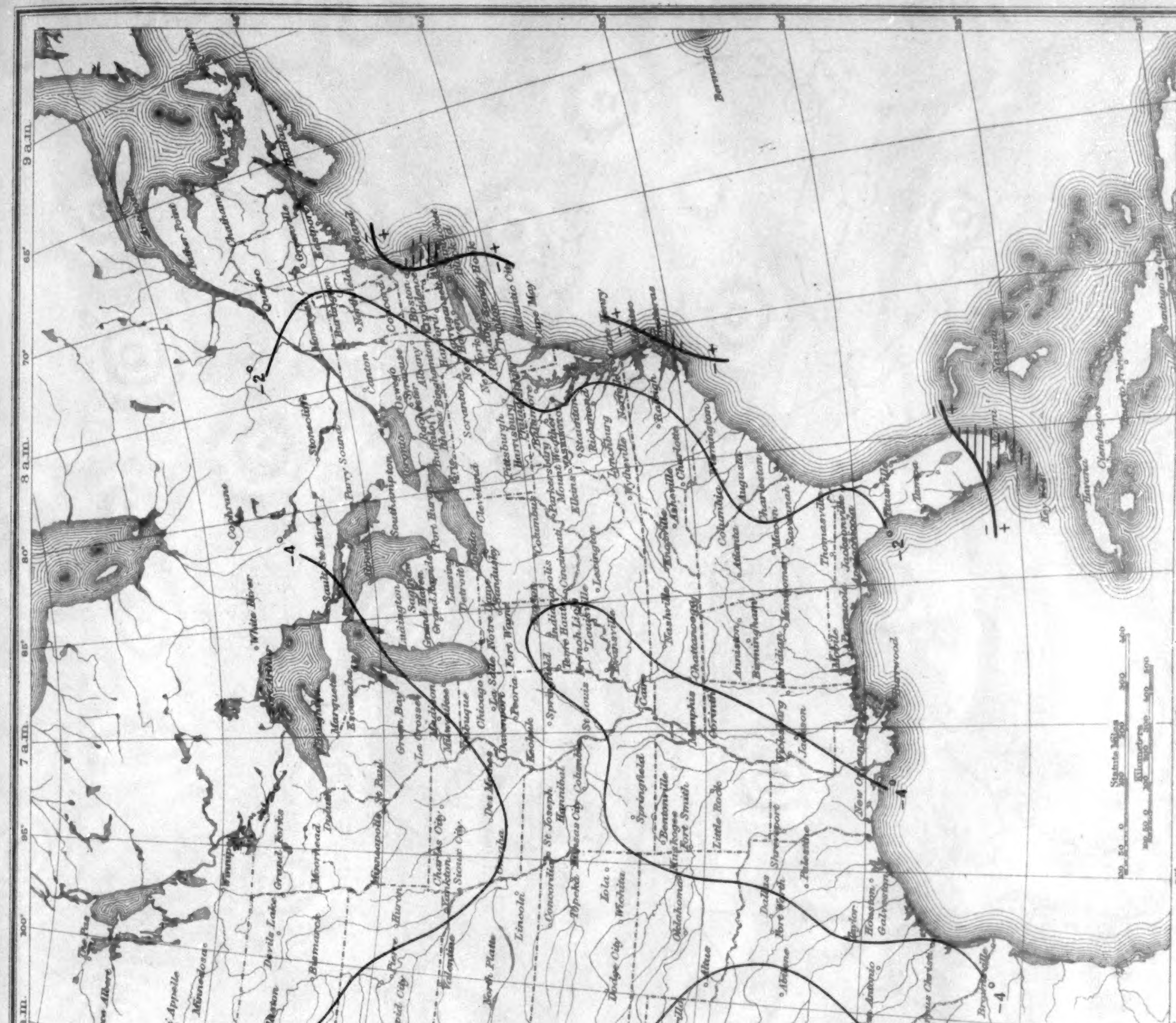

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.

Chart II. Tracks of Centers of Anticyclones, April, 1928. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

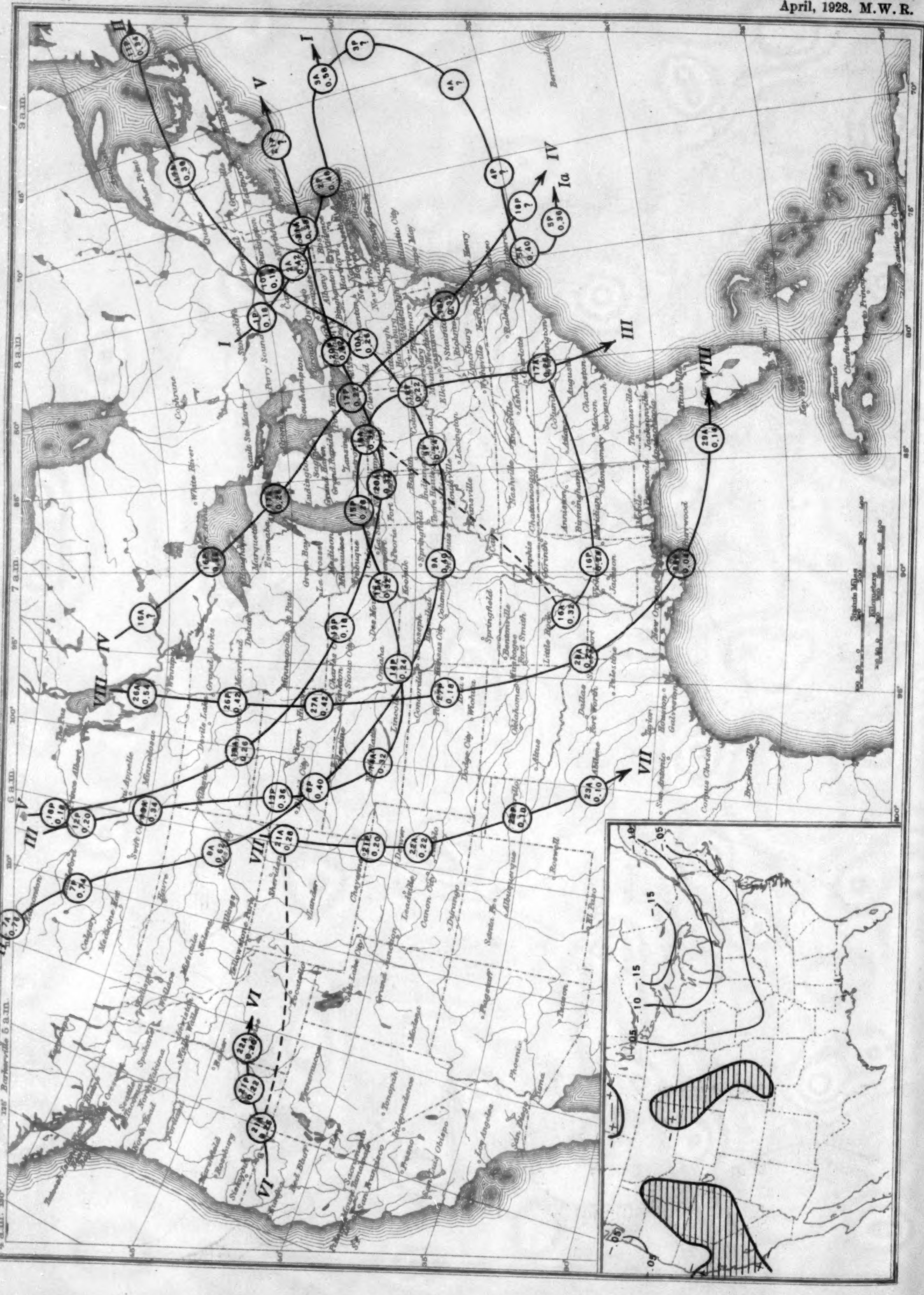

Chart III. Tracks of Centers of Cyclones, April, 1928. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)

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(Plotted by Wilfred P. Day)

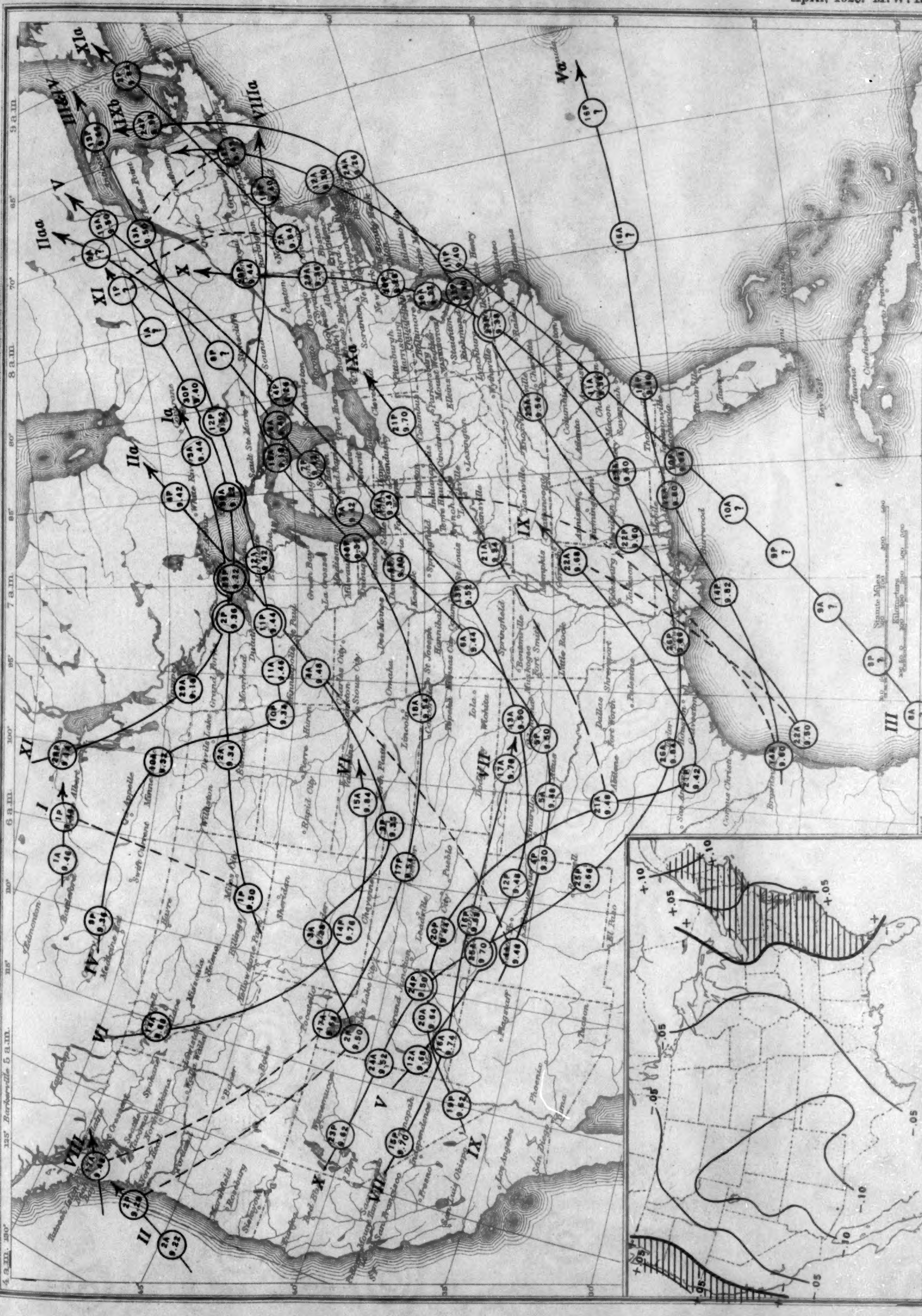


Chart IV. Percentage of Clear Sky between Sunrise and Sunset, April, 1928

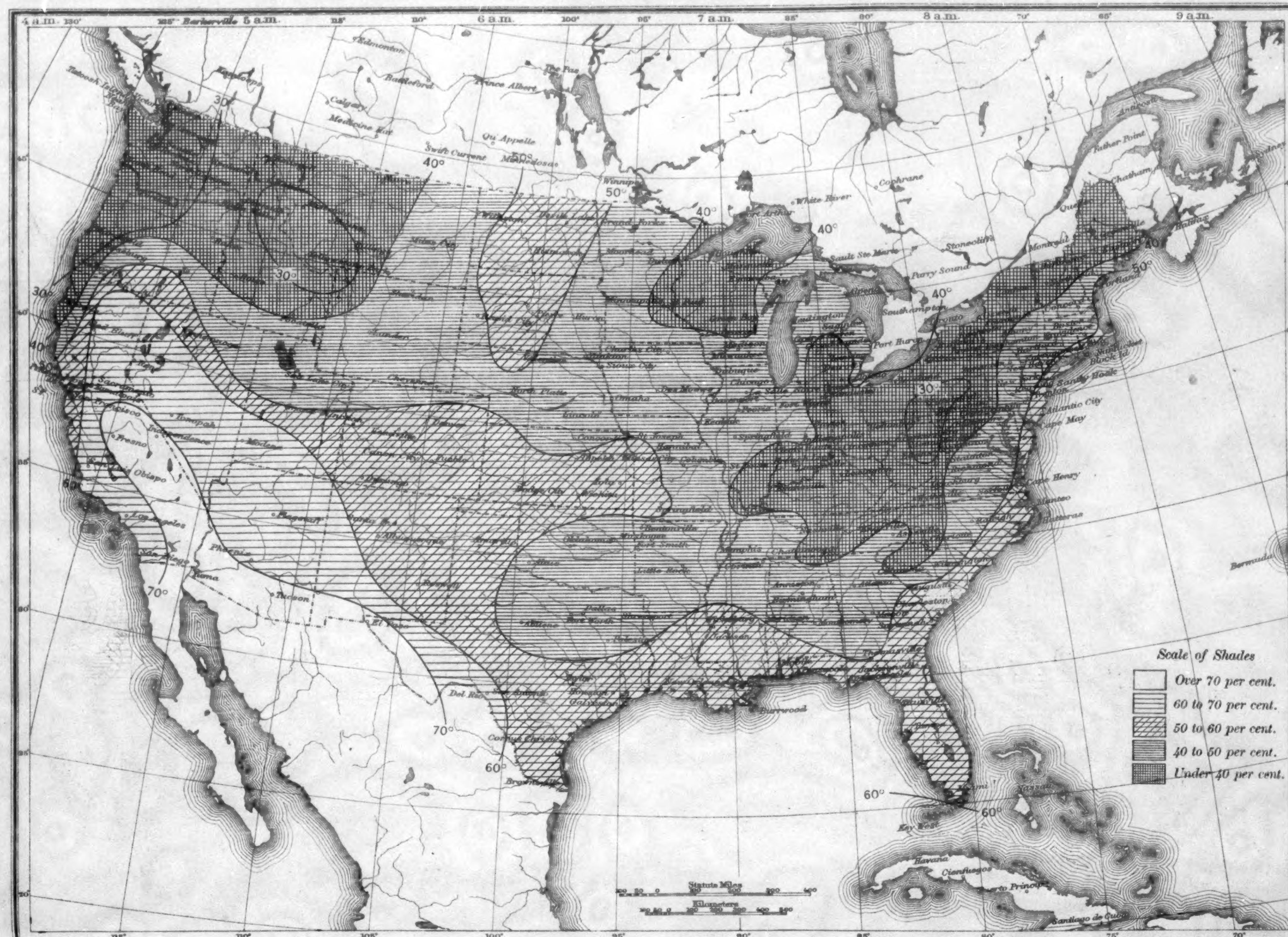


Chart V. Total Precipitation, Inches, April, 1928. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, April, 1928. (Inset) Departure of Precipitation from Normal

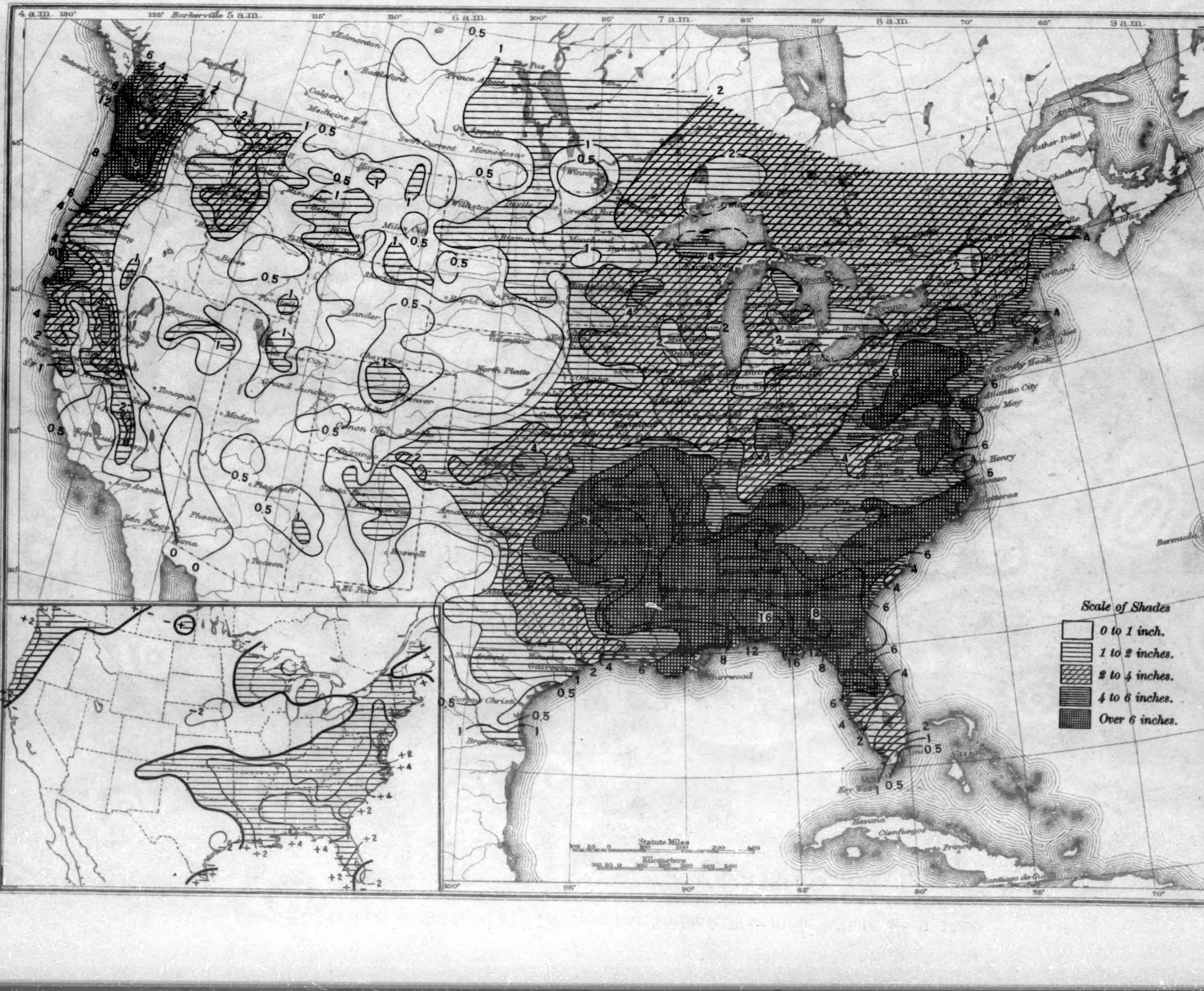


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, April, 1928

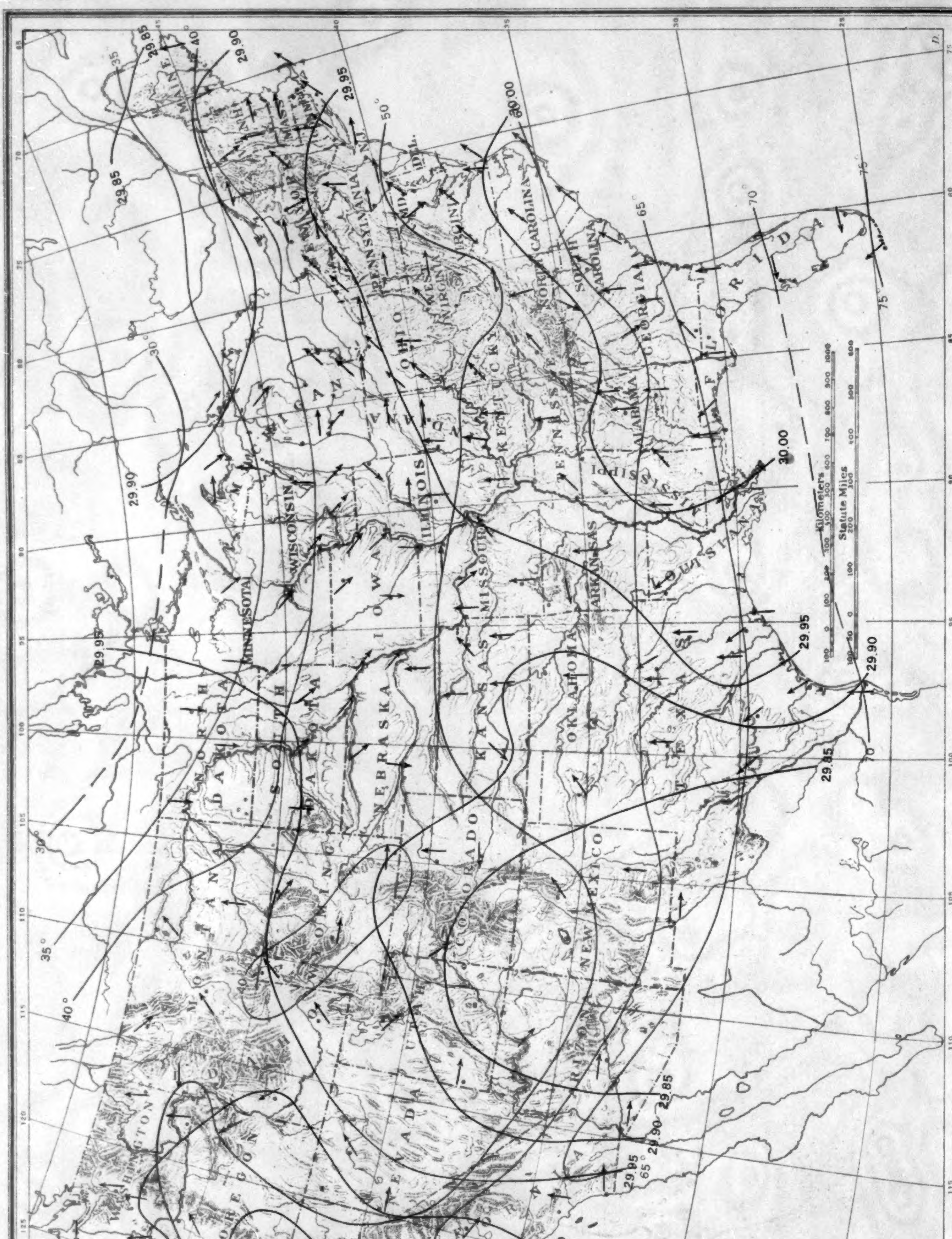


Chart VII. Total Snowfall, Inches, April, 1928.

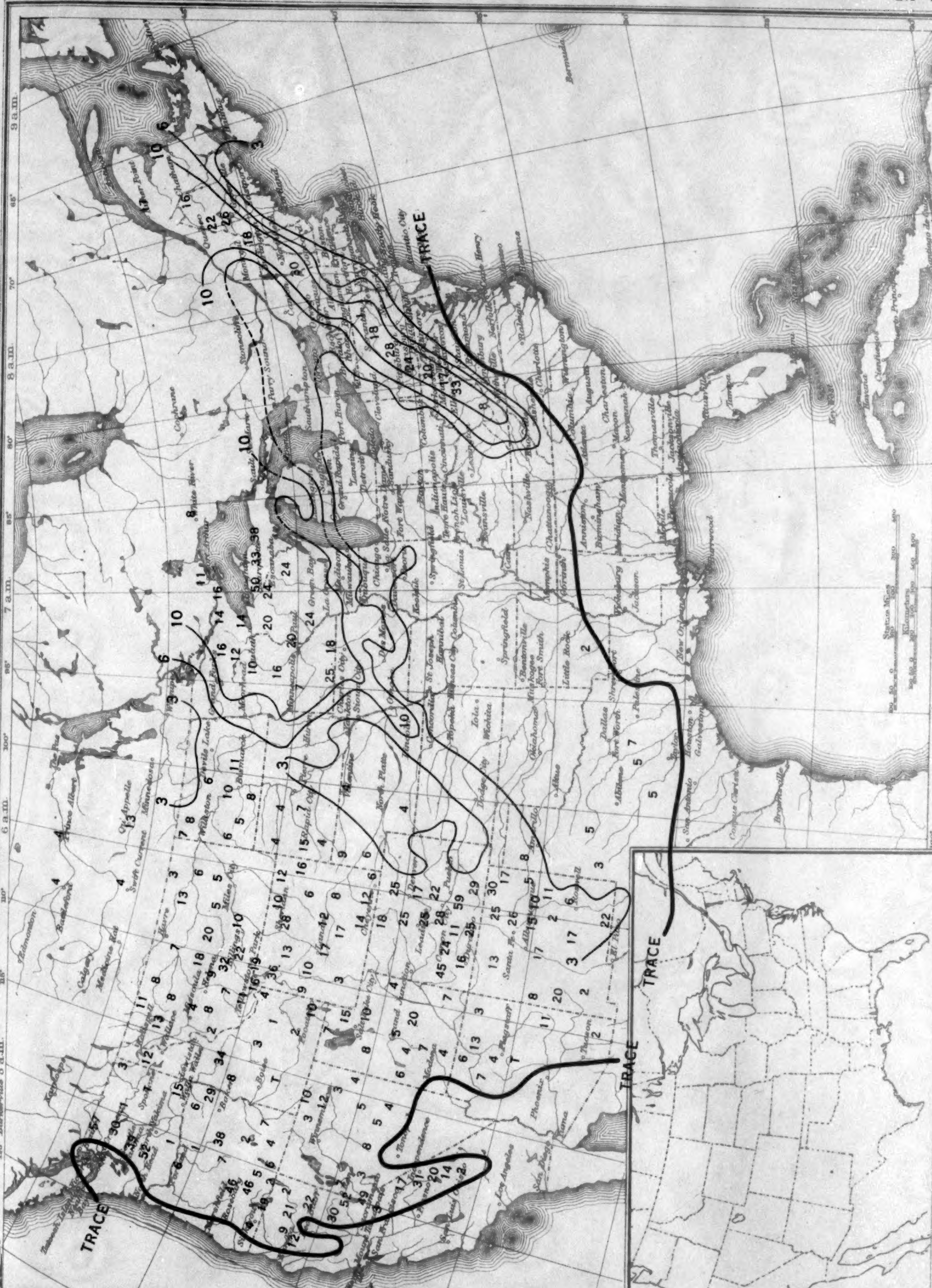
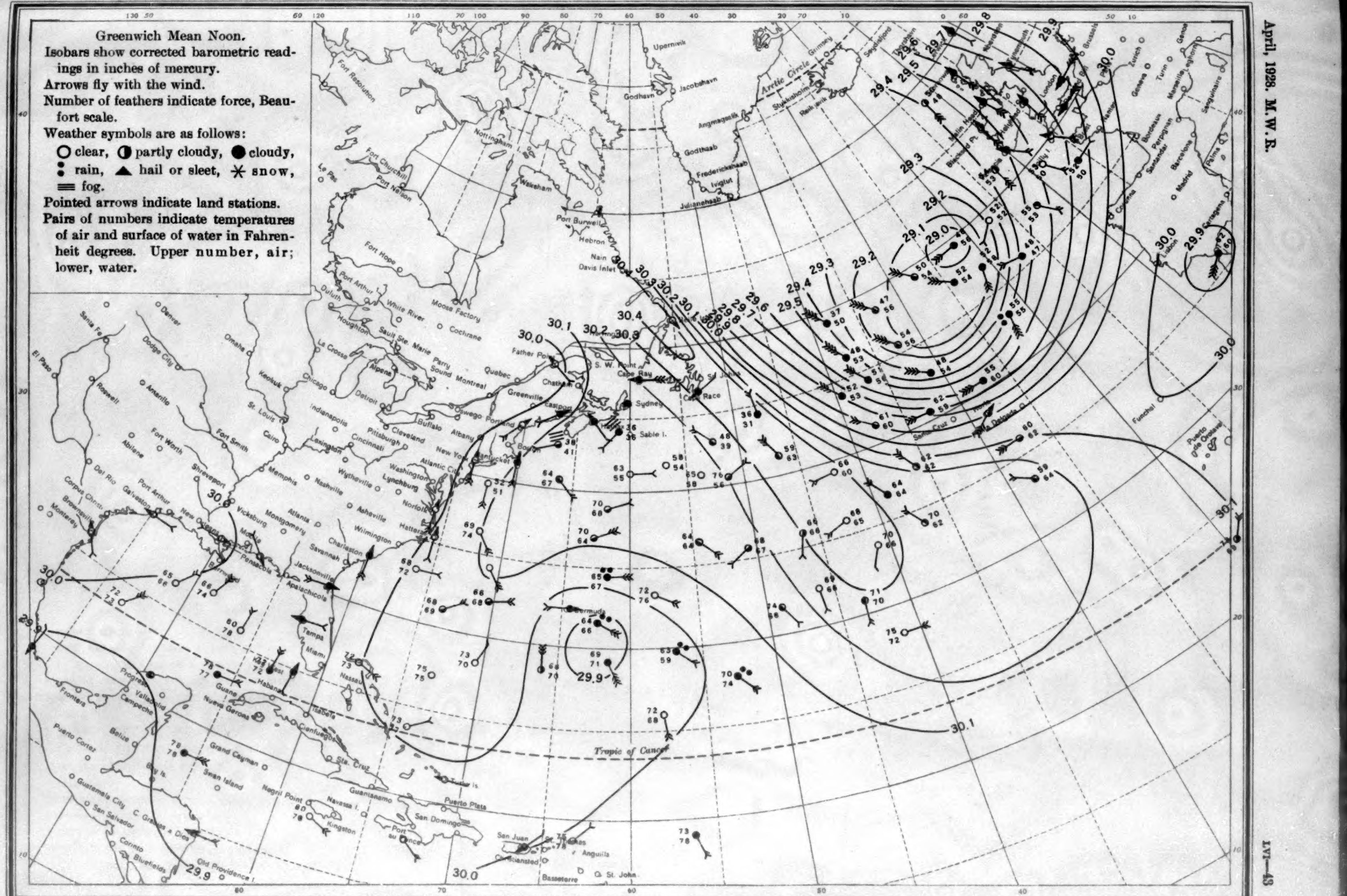


Chart VIII. Weather Map of North Atlantic Ocean, April 7, 1928
(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, April 7, 1928

(Plotted by F. A. Young)



Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Chart IX. Weather Map of North Atlantic Ocean, April 8, 1928
(Plotted by F. A. Young)

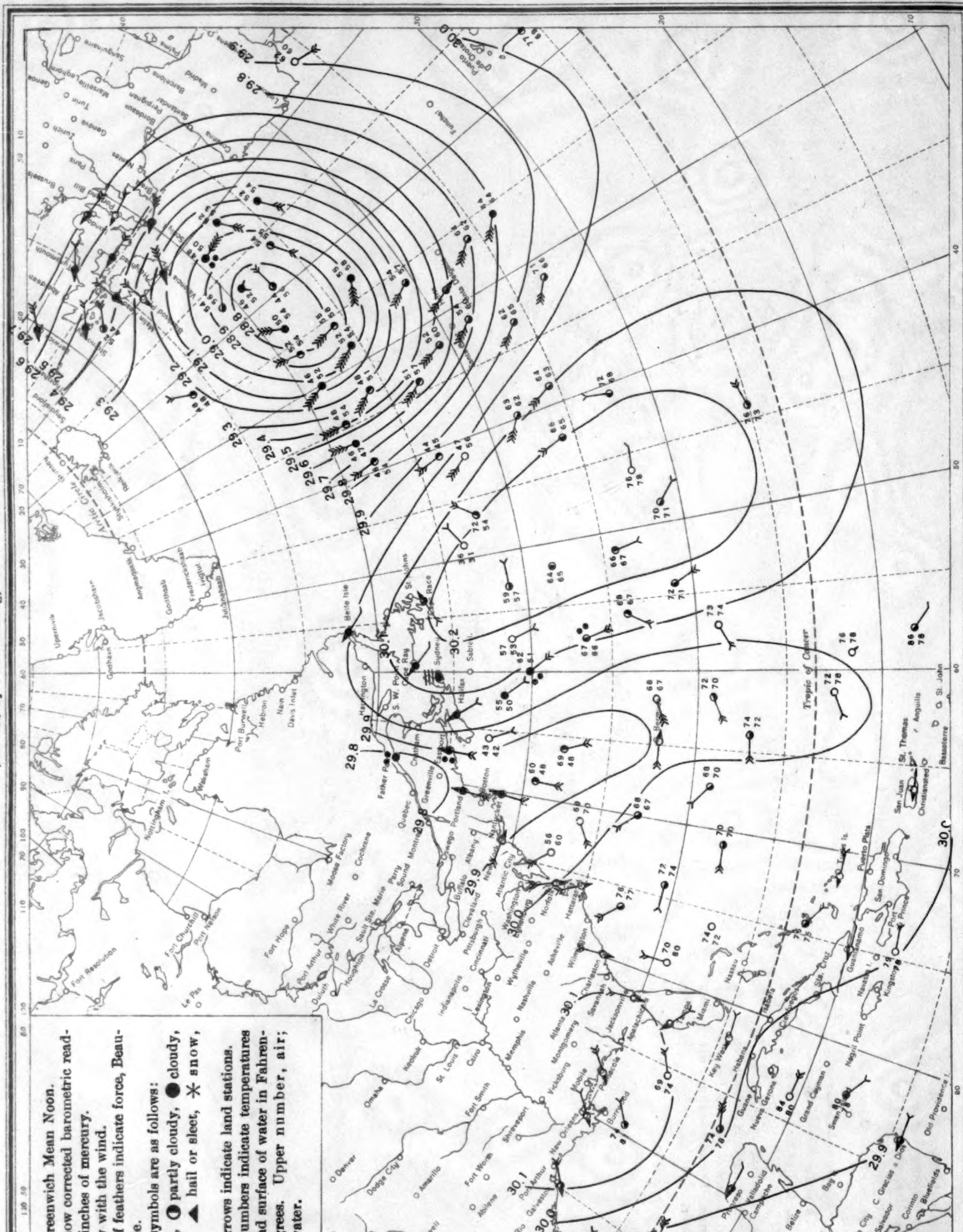


Chart X. Weather Map of North Atlantic Ocean, April 9, 1928
(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, April 9, 1928
(Plotted by F. A. Young)

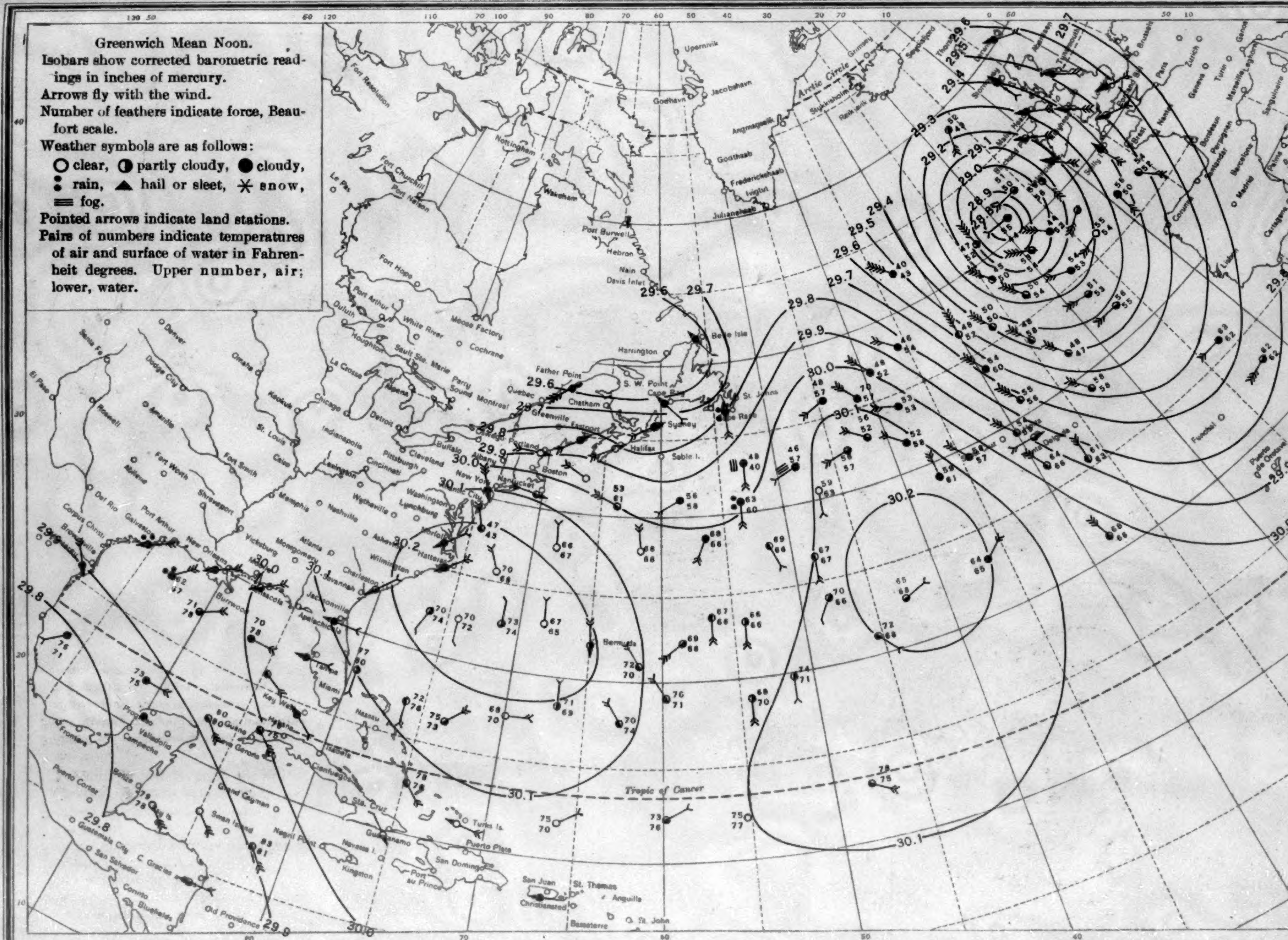
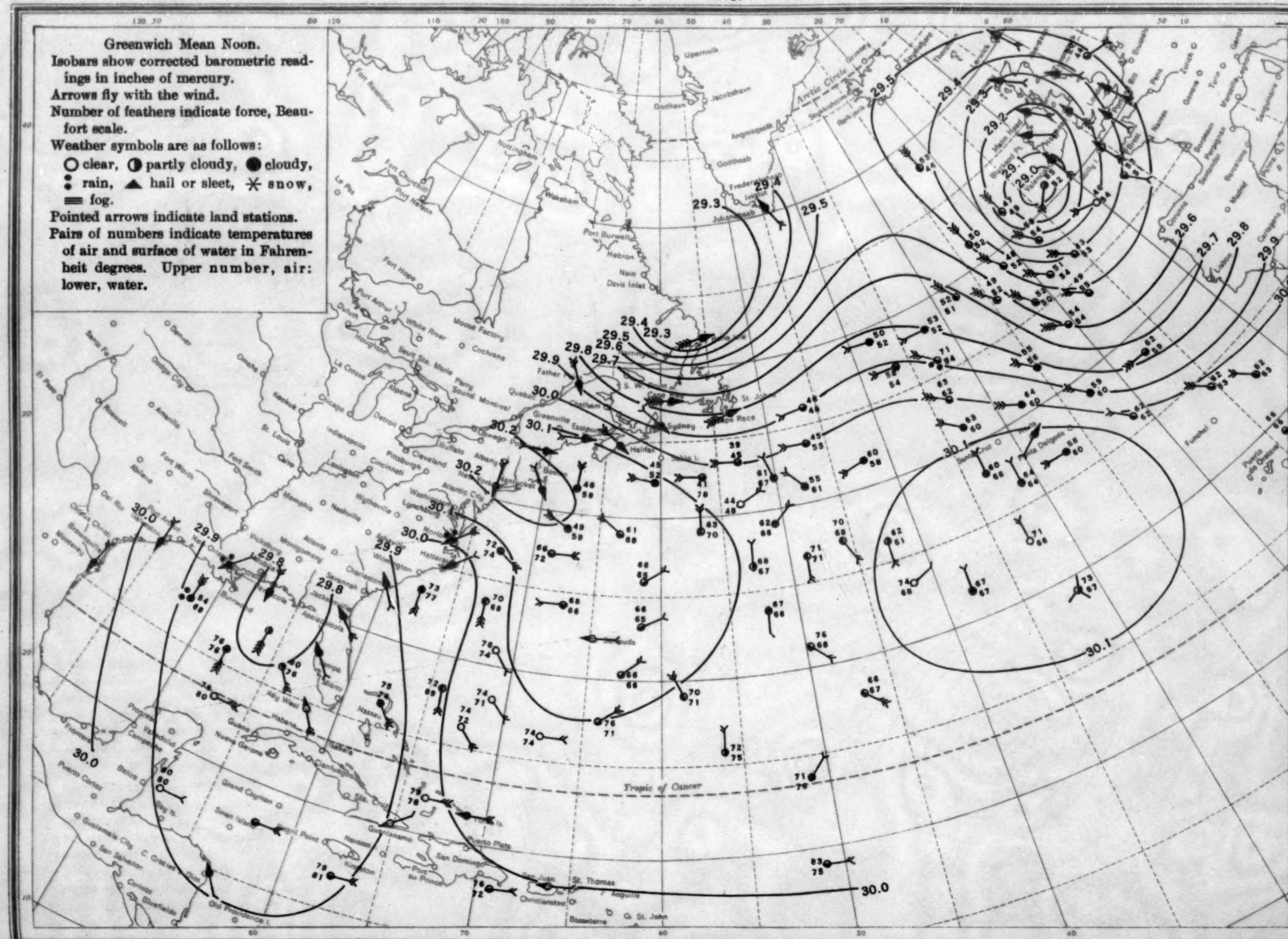


Chart XI. Weather Map of North Atlantic Ocean, April 10, 1928

(Plotted by F. A. Young)



Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:
○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air: lower, water.